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SELAGINELLA RUPESTRIS AND ITS ALLIES*

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These are small plants, hardly exceeding a few inches in height, yet they are a striking part of the vegetation of the semi-arid and subalpine regions of western North America, covering barren soil and festooning rock ledges. The forty-three species included in this study comprise the section *Tetragonostachys* of subgenus *Selaginella*. Thirty-two species occur in America, eight in Africa and Madagascar, and the remainder in Asia. Superficially they appear similar and nondescript but under magnification they reveal structures of beauty in design and symmetry which amply reward the student who takes more than a casual interest in them.

Selaginella rupestris and its allies occupy a unique place in xeric ecology for they are vascular plants adapted to being completely desiccated and reviving a few hours after moisture becomes available. Study of their physiological response to arid conditions would be of interest. In a number of ways the group offers data of value in geographic and evolutionary studies. S. *rupestris* is of particular cytological and geographic significance because it has both sexual and apogamous races, the latter occupying a much larger territory than the former. In this species, as well as the others, details of the life-cycle, especially the means of fertilization and of dispersal, are poorly understood. Aside from botanical collectors and browsing by deer in lean seasons, they are relatively unaffected by animals or man and the habitats which most of them occupy are relatively little affected by fire, lumbering, grazing or cultivation. Studies of the group may be of comparative value in relation to species in which the activities of man have played a critical role.

The principal effort in the present study has been directed toward a definition of the species and groups of species within a coherent framework of characters, to place the nomenclature on a firm foundation through reference to holotype material and to provide keys and illustrations to facilitate accurate identification. It is not to be expected that the keys and descriptions can be used by a student of the vascular plants without some introductory study of a few species, and indeed this

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is true of most genera. One can not successfully divorce the use of a monograph from specimens and it is not my intention that this treatment be wholly independent of such material.

THE PRESENT CLASSIFICATION

The taxonomy of the *Selaginella rupestris* group is beset with a number of difficulties which must be recognized and resolved before an adequate classification can be developed. The first, and perhaps most important, is the relative plasticity of the characters, not only of the vegetative parts, but of the strobili, sporophylls and spores as well. This does not mean that taxonomically useful characters do not exist but that considerable caution must be used in choosing those of specific value.

Relatively few species possess distinctive traits; rather most of them must be defined in terms of a particular combination of characters. There is evidence that there has been a great deal of parallel development in the group and that the potential variations of different structures have been realized many times. This situation has made it troublesome to find the morphological coherence of a species and the differentiating characters. Another difficulty is the very numerous characters that present themselves for consideration. In many groups, students probably feel the characters are too few and wish for more but a superabundance of them can be equally trying. The inadequate nature of most herbarium specimens has been a source of confusion for nearly all of the early collections and many contemporary ones are fragmentary. Complete mats of some fifteen species were collected in the field and notes were made on local variations of habit and habitat. With the information obtained from these studies, it was possible to understand the relation of herbarium fragments to the living plants. The minute nature of the characters has undoubtedly resulted in many of them being overlooked or misinterpreted. For example, the deciduous setae of *S. eremophila* were not detected until many years after the species was described. A relatively high magnification is needed to see the structures accurately. For general observation of the leaves and sporophylls 30 diameters is recommended, 40 diameters for the smaller details.

Inasmuch as the species must largely be defined in terms of combinations of characters rather than distinctive ones, a set of specific characters for each species does not exist by itself but only in relation to other species. One set of characters may distinguish a species from its close relatives, additional ones, or another set, may distinguish it from less closely related species. It is obvious, therefore, that before a species can be worked out, the groups of species must be defined to establish the circle within which character comparisons will be made. The following method was used to form a basis for grouping the species into natural units.

Some twenty-five presumed species of which complete material was available early in the study were scored for about thirty characters. These included some from all parts of the plant. Their value was not known although only qualitative ones were used. Each species was compared with the others for the number of

characters in common. Those that showed definite affinities with each other were grouped together. An analysis was then made for characters which would distinguish between the groups. After a certain amount of modification and rearrangement, the series and their characters were established. Such a method has a number of limitations that might make the results obtained inaccurate but when used with discretion it undoubtedly has value. The final test of the classification was the integration of some fifteen species not originally included. These took natural places within the system in regard to their geography, morphology and phylogeny.

Although many characters had been used by previous authors for the definition of species these were at first disregarded to remove all prejudice as to their possible value. The numerous available characters were reduced to a manageable number in two ways. It was assumed that lineal measurements should be avoided, if at all possible; that qualitative differences should be used for the primary characters of species. Quantitative characters of real value could be used as expressed by ratios. Structures that were variable on individual stems and within individual mats would not be reliable for taxonomic use and many characters were rejected for this reason. When the number of possibly useful characters was reduced to convenient proportions, several species were chosen to be analyzed for the characters of specific value. These were species such as S. *cinerascens*, S. *Bigelovii*, S. *oregana* and S. *tortipila* of which I had ample material and which have a distinctive morphology, a compact and natural range and a rather defined ecology. Each was examined to determine the structures that were sufficiently stable to be used as specific characters. The species were then compared with each other in terms of this final set of characters and it was found that the entire set was usable to express species differences. Such characters were then used to define the species within each series. Most of the species thus derived were found to have the following attributes: a set of sufficiently stable characters so that the "population" showed morphological cohesion; complete morphological distinction from other species; a degree of morphological cohesion and distinction that is qualitatively and quantitatively comparable to other related species; a natural geographic distribution, allopatric or largely so from related species; and a definite local ecology although this might be rather broad within the whole range. These characteristics were used as criteria for determining the category in difficult and perplexing cases. The "good" species of the section, therefore, defined themselves, their attributes were determined and the other species were defined comparatively in similar terms. Subspecific categories were defined in relation to the species.

The category subspecies is used in S. *arenicola* where the major variants have not completely developed the properties of species. The variety is used in three species but only one of these may be considered a proper example of the use of that category. That is in S. *mutica* where the two variants, although definite, have the characteristics of species poorly developed. In the case of S. *Wightii* the two varieties are recognized largely for practical reasons, the material available being

insufficient to establish the proper category. In S. *densa* a most interesting but quite unsatisfactory taxonomic condition exists. The three variants are quite distinct morphologically and geographically over large areas in the northern part of the range of the species. Here they would certainly rank as subspecies and perhaps even as species although the characters that separate them are not quite as well developed as in other species in the series. But the varieties all grow in the large central portion of the range where they exhibit such complete intergradation in characters that only one highly variable species could be recognized. I have chosen to use the category variety for them, placing perhaps a bit more emphasis upon their intergradation than upon their distinctiveness.

The species descriptions have all been taken directly from the keys and are uniform only within each series. All of the characters mentioned in the species key are included in each description. Although this is a departure from the usual procedure, it is necessary in order to emphasize the set of characters important within an evolutionary line. A number of characters used in this treatment are peculiar to the genus or at least not commonly used in vascular taxonomy. For these I have tried to use suitable descriptive terms or phrases often without intending precise definition. I quite agree with Mr. Weatherby's views that: "An attempt to find other characters which, even if seemingly incapable of altogether definite statement, could be more easily seen and better relied upon, seemed worthwhile."[1] I have used many of the characters that he introduced and some new ones.

Although it was not my original purpose to enter into the general classification of the genus in any way, it finally did seem necessary to give formal recognition to the major groups of species. The erection of the series has caused in turn some slight readjustments within the subgenus. These changes are presented in the synopsis of the subgenus.

THE BACKGROUND OF THE STUDY

L. M. Underwood was the first botanist to give serious attention to the *Selaginella rupestris* group. His first paper, in 1898[2], clearly expressed the condition of the classification at that time: "The variations of the species of *Selaginella* with many-ranked leaves have long been a puzzle to botanists . . . . Two clearly marked species from North America have been separated from the tangle already; . . . . there remain . . . . the widely varying forms that for the past forty years have found an unsatisfactory resting place under S. *rupestris*." Underwood described a total of nine new species in unraveling "the tangle"; I maintain seven of them.

He was in correspondence with Hieronymus at Berlin and they exchanged specimens of many species in the group. Hieronymus did the *Selaginellaceae* for Engler & Prantl's 'Natürlichen Pflanzenfamilien'[3] and prior to and following this work described many new species in the genus. In the S. *rupestris* group he pro-

[1] Jour. Arn. Arb. 25:409. 1944.
[2] Bull. Torr. Bot. Club 25:125–133. 1898.
[3] Nat. Pflanz. 1[4]:621–715. 1901.

posed twenty-eight species[4] of which I recognize eleven. Hieronymus deserves credit for his general position that a multiplicity of species existed and for his attempts to work them out. His work suffered for reasons that were largely either beyond his control or else in harmony with the times. His material was scrappy and inadequate, sometimes hopelessly so. Also his concepts of the natural distribution of species, particularly those of the United States, were not well developed. Finally, he relied largely upon quantitative characters of the leaves, setae and cilia, many of which have proved to be of little value. The considerable number of his species that are valid is probably due to the fact that he did have material of many species.

The last worker to describe many species was Maxon[5] who published eight new ones from the United States. All but three of these I recognize as valid and two of those three are recognized as varieties. Maxon not only described most of the new species remaining in the United States but in his treatments of *Pteridophyta* for various floras of the western United States he supplied keys for their identification. The work of Underwood and Hieronymus was largely consolidated and systematized by Maxon and a knowledge of most of the species of the United States was placed on a firm foundation by him. His knowledge and judgment of the species were excellent but probably because his work in the genus was primarily floristic he separated the species on the most convenient characters and did not develop a set of characters useful for the whole group. Also, he relied in his descriptions too strongly, in my opinion, on quantitative characters.

Prior to the studies of Underwood, Hieronymus and Maxon, the species were poorly understood. The most common policy was to place all material under the name of *Selaginella rupestris;* a few authors segregated varieties or forms of it; a very few segregated species. This early work is reviewed although it did not play an important role in the classification of the group.

The species named *Lycopodium rupestre* by Linnaeus[6] was, as many he treated, previously well known. Among several earlier figures of the species, that of Dillenius[7] is the best. It presents an excellent illustration of the plant from Virginia. Linnaeus combined Virginian and Siberian plants in the same species and this broad range was enlarged upon by later authors until finally S. *rupestris* was credited with essentially a world-wide distribution. At that time it included many diverse species. Beauvois[8] segregated *Selaginella* and other genera from *Lycopodium* in 1805. He placed *Lycopodium rupestre* in his genus *Stachygynandrum*. Spring, Milde and A. Braun were the principal monographers of *Selaginella* in the nineteenth century and they recognized, to a greater or lesser extent, the variability within S. *rupestris*. Spring[9] grouped his material on the

[4] Most of them in Hedwigia 39:290–320. 1900.
[5] Most of them in Smiths. Misc. Coll. 72[5]. 1920.
[6] Sp. Pl. 2:1101. 1753.
[7] Hist. Musc. t. 63, fig. 11. 1741.
[8] Prodr. Aetheog. 101. 1805.
[9] Nouv. Mém. Acad. Roy. Belg. 24:57. 1850.

basis of habit, the rather short-stemmed northern species forming his S. *rupestris* var. *borealis* and the generally elongate and lax southern ones his var. *tropica*. Milde[10] used an essentially geographic segregation, recognizing as *formae* of S. *rupestris* material from several countries and regions. Of the ten forms he lists, I recognize seven as species. A. Braun[11] also recognized variants of S. *rupestris* as they occurred in Africa, using some obvious characters of the leaves, cilia and setae. Primarily due to floristic work, by the time of Underwood's treatment the following species were usually recognized as distinct from S. *rupestris:* S. *Dregei* Presl, S. *tortipila* A. Br., S. *oregana* D. C. Eaton and S. *echinata* Baker.

The present authority on the genus as a whole, A. H. G. Alston, has treated a number of species in the S. *rupestris* group, especially as they have occurred in his regional treatments. Outside of the United States and Mexico the species are rather few and he nowhere has had to deal with a sufficiently large number to seriously engage the problem of specific characters. His work may be ranked with that of Maxon, placing our knowledge of the species of South America, Africa, Madagascar, India, China and northeastern Asia on a firm foundation.

It will be noted that the species of Mexico had not been treated. This was probably due to the feeling that there was not sufficient material available to make it possible to deal successfully with the many species suspected of being present. The first worker to accept this difficult problem was C. A. Weatherby[12, 13]. In his two papers he was the first, from the point of view of this treatment, to derive a general set of specific characters and to start grouping the species into natural units; he was also the first to understand the special nature of the S. *rupestris* group and to adapt his classification to it. Mr. Weatherby's publications on *Selaginella* epitomize rather well his publications in systematics as a whole. His output was not voluminous but he had a strong predilection for the poorly understood groups and in these his abilities resulted in treatments of basic and permanent value. It will be apparent to students of his papers that the present study is largely an extension of his work. This is fitting for my interest in the group stemmed from his.

Morphology and Life History

Most of the species have prostrate, superficial stems that are variously disposed to form a mat of more or less distinctive type. The stems of a mat may be interlaced and intricate as in S. *Underwoodii* (fig. 40) and S. *cinerascens* or discrete as in S. *densa* (fig. 47). The branching may produce a very compact mat as in S. *Watsonii* (fig. 49) or a loose, open one as in S. *mutica*. Growing conditions affect the form of the mat so that it is not stable in most species. Edges of cliffs, steep slopes, boulders and seepage crevices modify the habit of growth. In addi-

[10] Fil. Europ. Atlant. 260–263. 1867.
[11] Kuhn, Fil. Afr. 212–214. 1868.
[12] Amer. Fern Jour. 33:113–119. 1943.
[13] Jour. Arn. Arb. 25:407–419. 1944.

tion, some species may have the central stems crowded and rather erect and the peripheral ones closely prostrate and widely creeping. In S. *tortipila* the two types were described as separate species. A similar condition exists in S. *Hansenii* although fortunately they were not segregated. In these species the size of the mat is increased by growth of the apical buds. The older portions of the stems die progressively toward the apical buds and strobili. The dead portions may be rather evenly distributed throughout the mat or, especially in the species with discrete branches, they may be in the center or at one side (fig. 47). A strobilus-bearing branch dies completely since the strobili, with rare exception, are determinate. Vegetative apices are theoretically indeterminate although actually they do occasionally die.

The species of *Arenicolae*, with rhizomes or basal branch buds, form various shaped clumps or mats depending upon the extent to which the substrate permits or hinders the growth of the rhizomes or basal buds. S. *arenicola*, which usually grows in open sand, has quite symmetrical mats. In the species with rhizomes, as S. *Weatherbiana*, the rhizomes grow forward, occasionally branching or producing erect, aerial stems. These aerial branches produce a branch-system on which strobili are eventually produced and a short time later the whole branch-system dies. Most of the apices die due to the determinate strobili produced although the vegetative tips also die. This may be due to the death of the portion of the rhizome beneath the aerial branches or because of the distance the apices have grown from the nearest roots. New aerial branches produced by the younger parts of the rhizome perpetuate the plant. The leaves of the rhizome are generally similar to those of the aerial stems (compare figs. 7 and 8) but are usually broader, thinner, have a shorter seta and cilia, have a less-developed dorsal groove and the living ones are pale tan or a very pale green. S. *arenicola* and S. *rupincola* lack rhizomes but have short buds at the base of the erect aerial stems (figs. 1, 5). These buds become active upon the death of the branch-system; each developing into a new branch-system. This results in a rather bushy habit unless, as is often the case in S. *rupincola*, growth is modified by rock crevices.

The stems often branch dichotomously but this is not the predominant type of branching in any of the species. The branching pattern is formed by laterals variously subordinate to the main stem, distance between branches and the angle at which they depart from the stem. Although this is obviously different in some species the degree to which it may be modified by growing conditions makes it an unreliable taxonomic character. A branch will remain subordinate to the stem upon which it is borne until the two apical buds are sufficiently removed from each other and then it will grow more rapidly. This seems to occur at about the time the stem and branches are separated by the death of the older portions. Branches of the second and third order are also subordinate to their respective main stems. In three species, S. *utahensis*, S. *leucobryoides* and S. *asprella*, the stems are fragile when dry and are easily broken even with careful handling. The anatomical nature of this character has not been investigated.

During periods of unfavorable growing conditions the stems become dormant. It is probable that many species have the ability to remain alive in the dormant state for many months. A specimen of *S. Watsonii* was planted three months after it had been pressed and dried and it put forth new growth. Part of a mat of *S. densa* var. *densa* was planted six months after it had been collected and stored as an herbarium specimen and it also grew. Various changes take place when the stem becomes dormant. In many species the branch tips curl upward; in *Eremophilae* they become involute. A considerable portion of the stem is involved and the dormant stems form ringlets in *S. oregana*. This curling of the stems recalls the behavior of *S. lepidophylla* and its relatives, the commercial Resurrection Plant. The leaves also change position, becoming more or less closely appressed to the stem. These changes are particularly marked in the strongly dorsiventral species in which the spreading lateral leaves almost completely enfold the upper ones. However, the erect upper leaves do not perceptibly change in position. In some species as *S. tortipila* the leaves are usually rather closely appressed in the growing state and change position very little when desiccated. The difference in position of the leaves of a species in the growing and dormant states is not sufficiently constant for general application. This behavior, however, has a distinct advantage to the taxonomist for it renders herbarium material as useful and as valid as living material for most characters of the plant. Conclusions as to the relation of living to herbarium material were confirmed by comparisons of specimens collected from species growing in the greenhouse. There is no difference between the living dormant plant and the herbarium specimen prepared from it. Soaking the specimen in water will restore it in the same way as watering the living plant. Specimens prepared from actively growing plants will assume the characters of the dormant state upon drying with the exception that portions subject to pressure in pressing will be held in more or less the original position.

I have not measured the growth of the stem of any species in its native habitat but measurements of material grown in the greenhouse indicate that it usually amounts to 1–4 cm. a year. During 100 days in the greenhouse, *S. arenicola* ssp. *Riddellii* grew 30 mm. and *S. viridissima* grew 15 mm. although this may not reflect the relative growth rates of the species in their natural habitats. A specimen of *S. tortipila* (*Hunnewell 9478*, GH) appears to show annual growth of 13 mm. on some of the stems.

The leafy stem is radially symmetrical in many species, that is, the leaves are disposed in the same manner on all sides of the stem at a given place and they are of the same size, shape, color and texture. This is true of the species that have erect stems and many of those that are prostrate. Most of the species with stems rather closely appressed to the ground are more or less dorsiventral. Extreme dorsiventral species such as *S. Landii* (figs. 62, 63) and *S. echinata* have the under leaves tightly appressed to the stem, the upper erect, the lateral ascending-curved, the under leaves longer than the upper, different in shape, thinner, tan or brownish, and the setae also differ. All intermediate conditions occur, some species having

one or more dorsiventral characters so that there is not a sharp line of distinction between radial and dorsiventral symmetry.

Leaves are the most useful part of the plant for purposes of taxonomy and a number of characters of the position, base, apex, shape, texture, cilia and seta have been used in this treatment. The base of the leaf, in some species, is abruptly adnate to the stem and distinct from it in color. In other species the leaf-base is decurrent, gradually blending into the stem in form and color. Red leaves often occur in S. *Sartorii*, S. *Steyermarkii* and S. *Hansenii*, especially in the area between the oldest living leaves and the youngest dead ones. (fig. 23, the dark portions of the leaves are red). These are often a bright red or tinged with purple. They perhaps develop color in a manner similar to the sugar maple and other deciduous trees in northern regions. A few double leaves have been observed. The leaves are firm in texture with the exception of S. *oregana* in which they are sufficiently soft and thick so that they partly collapse in drying.

The usual sequence of leaf development appears as follows. At the beginning of the growing season relatively few green leaves are present at the apex of the stem but renewed growth of the apical bud produces new leaves and a conspicuous zone of green leaves develops. After a time the oldest of these die; those that were green at the start of the growing season die first. Under rather uniform conditions the death of the older leaves proceeds at a rather constant rate and probably at a rate similar to the production of new leaves so that a zone of green leaves of rather uniform length is maintained. During 100 days in the greenhouse, leaves died on 11 mm. of stem in S. *mutica* and on 39 mm. in S. *arenicola* ssp. *Riddellii*. Toward the end of the growing season, or with the advent of a dry period, the leaves continue to die, although no new ones are produced, until sometimes only a few green leaves near the bud remain.

The apparent inhibition of growth of lateral branches has been discussed. In some species the leaves are affected in a similar manner. In S. *cinerascens*, for example, the leaves on the main stem are the longest and those on the primary, secondary and tertiary branches progressively shorter. However, once the branch apex is separated from the stem apex by the death of the older portions, the leaves that are produced are as large as those on a main stem.

The strobilus is nearly always determinate but vegetative growth from its apex does occur. This is not uncommon in S. *arenicola* ssp. *Riddellii* and I have seen two other examples of the condition: S. × *neomexicana* (*Slater 3*, US) and S. *arizonica* (*A. & R. A. Nelson 1158*, MO). This condition was noted in S. *densa* planted in the greenhouse in a dormant condition that produced vegetative tips on two strobili upon renewal of the growth of the mat. I have seen one strobilus that was dichotomous (*Soxman 351*, US), a specimen of S. × *neomexicana*. In most species the sporophylls die progressively upward after the death of the leaves on the leafy branch beneath. In S. *arenicola* ssp. *arenicola* and ssp. *acanthonota*, and to some extent in S. *Dregei* and S. *tortipila*, the apical sporophylls die first and the basal last, and this occurs prior to the death of the leaves beneath so that the death of the strobilus is independent of the progressive death of the leaves.

The sporophylls are hinged by their stalks to the strobilus axis and when the spores mature and the sporangia open they move outward presumably in response to their water content. This movement evidently aids in the dispersal of the spores. Although I am not certain, the two valves of the sporangium may also move. I have observed in *S. rupestris* that megaspores will frequently remain in the basal sporangia after all of the others are shed, apparently because the leaves directly beneath do not allow the sporophylls to move sufficiently. Occasionally spores are found in dead strobili, and thus their liberation from the sporangium is not always effected.

I have seen sporelings in only a single collection and germinated megaspores were never observed on the specimens. Megaspores were germinated on filter paper in a petri dish and then were dried. The triradial split in the spore coat and the gametophyte were still evident; thus if germinated megaspores had occurred in the collections they could have been recognized. Lyon [14] reports germination of the megaspores within the sporangium, and fertilization of the gametophyte prior to dispersal from the sporangium. I have observed nothing to support this but since the species do have natural ranges, many of them over considerable areas, it would seem that the normal life cycle is completed. Possibly germination and fertilization occur at rather rare intervals when the microclimate is particularly favorable. This may occur in the sporangium, as Miss Lyon observed, or after the spores have been shed. Since the stems of most species are quite tough and difficult to break, and are usually anchored at frequent intervals by the rhizophores and roots it does not seem likely that vegetative reproduction could account for the distribution of the species. In the group of species with fragile stems, *S. utahensis*, *S. leucobryoides* and *S. asprella*, it is not unreasonable to consider that fragments might be dispersed by the wind although actually they are all rather local endemics. Their restricted ranges, however, may be due to other causes and they may still possess an effective means of dispersal.

In *S. rupestris*, which is apogamous throughout much of its range, fertilization is not a factor and the megaspores may be effectively dispersed immediately upon release from the sporangium. *S. rupestris* has the widest distribution of any species in recently available areas and its range may be taken to illustrate the effectiveness of megaspore dispersal. I have seen sporelings growing in the soil among the stems of a mat of *S. sibirica* (*Calder & Billard 2995*, MO). These are about 1 cm. long and inside the megaspore a foot can be seen from which are produced one to three roots and an erect stem. This stem does not bear leaves for the first third to half of its length. The first leaves are thinner, more elongate at the base and more widely spaced than the adult leaves. Those at the tip of one of the sporelings are of the adult type in aspect and disposition; the other two sporelings have only juvenile leaves. Two rhizophores had been produced on each sporeling, the first in the axil of the second or third leaf.

[14] Bot. Gaz. 32:124–141. 1901.

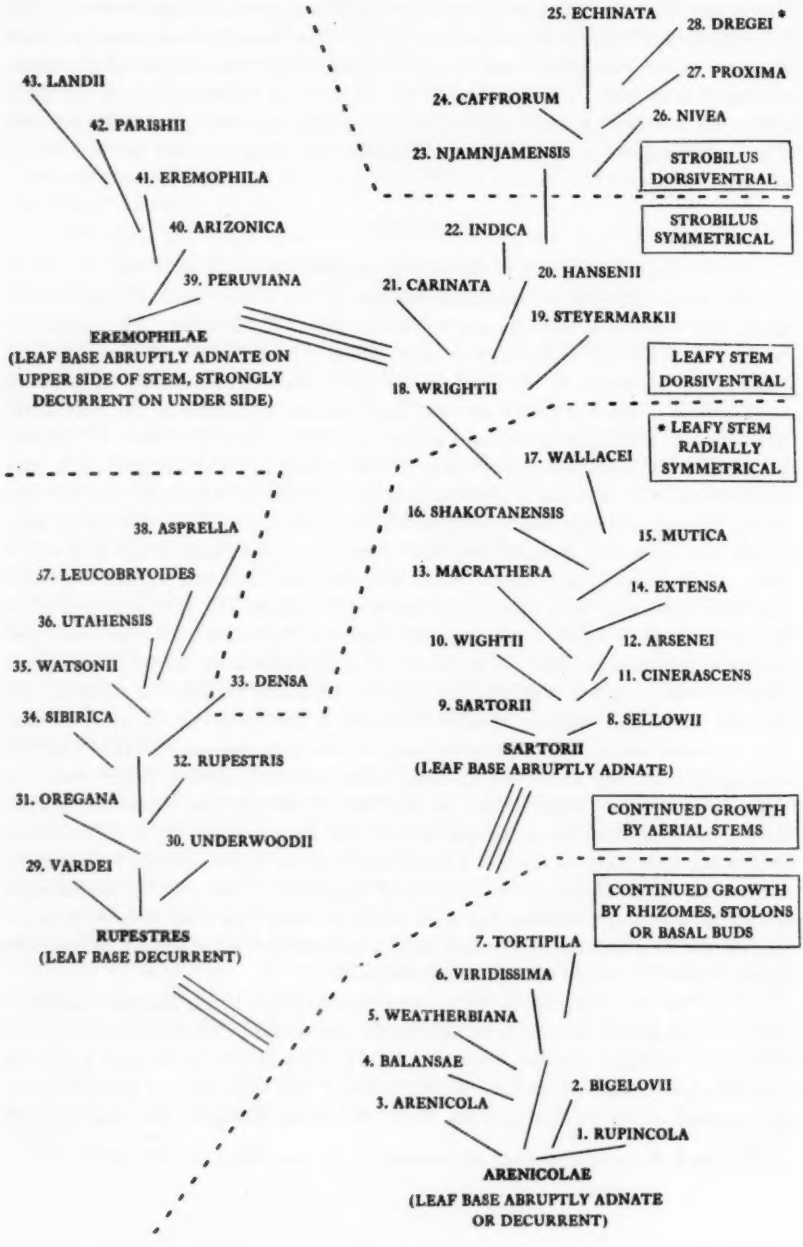
The chromosome number has been determined in S. *Weatherbiana* (*Tryon & Tryon 5077*, 2n = 18), S. *mutica* (*Tryon & Tryon 5073*, n = 9, 2n = 18) and in S. *Bigelovii* (*Tryon & Tryon 5054*, n = 9). The sporophytic counts were made from the tips of rhizophores and the gametic ones from the contents of the megasporangia at meiosis. I am indebted to Dr. Amy Gage Skallerup for the considerable work involved in making these counts. These numbers agree with the ones for S. *selaginoides* (S. *spinulosa*), S. *helvetica* and S. *denticulata* given by Miss Manton[15] as n = 9.

Phylogeny

The phyletic chart portrays the general relationships of the series and the species within them. There is not sufficient evidence of the actual course of evolution to more than indicate in very general terms the origin of the series. The characters that are of particular importance in determining a primitive or advanced phyletic position are the nature of the leaf-base, abruptly adnate or decurrent, the presence or absence of rhizomes, stolons or basal buds and the symmetry of the leafy stem. *Arenicolae* is placed as primitive because it exhibits some characters of Section *Selaginella*, the most primitive section of the subgenus. The comparison is particularly effective between S. *arenicola* and S. *rupincola* of *Arenicolae* and the two species of Section *Selaginella*, S. *selaginoides* and S. *deflexa*. These four species have erect strobilus-bearing branches and have rhizophores borne only at the base of the stem. S. *rupincola* is not entirely uniform in the latter character in that occasional prostrate stems may have rhizophores borne throughout. S. *deflexa* is similar to S. *arenicola* and S. *rupincola* in that the vegetative branches are rather small and resume active growth upon the death of the strobilus-bearing branch above them. Thus S. *arenicola* and S. *rupincola* are the most primitive types in the section. This does not mean that they are actually ancestral to the species of the series or that they represent the transition from Section *Selaginella* to Section *Tetragonostachys;* but rather that they retain the ancestral characters to a greater degree than the other living species. *Eremophilae*, on the basis of its leaf-base characters, is considered to be the most advanced and *Sartorii* and *Rupestres* occupy a mid-position. Due to the limitations of space and the diversity of *Sartorii* it has not been possible to portray accurately the phyletic level of *Rupestres*. The radially symmetrical species of *Sartorii* are considered as more primitive than *Rupestres*, those with dorsiventral leafy stems and symmetrical strobili essentially on the same level and the species with dorsiventral strobili more advanced.

It will be noted that the habit of growth is uniform in the *Sartorii*, *Rupestres* and *Eremophilae* and distinct from that in the *Arenicolae*. The leaf-base characters behave in a different manner; they are stable and distinctive in *Sartorii*, *Rupestres* and *Eremophilae* but are variable in *Arenicolae*. The series *Sartorii* and *Rupestres* are regarded as differentiating from *Arenicolae* or its ancestors, the characters of

[15] Manton, I. Problems of cytology and evolution in the Pteridophyta. p. 259. 1950.



Phyletic chart of subgenus *Selaginella* section *Tetragonostachys*.

the leaf-base becoming fixed in each series and the same type of growth developing independently. The *Eremophilae* were derived from the *Sartorii* by further specialization of the leaf-bases. The development of the dorsiventral leafy stem has occurred independently in *Sartorii* and *Rupestres*. S. *Dregei*, with its radially symmetrical leafy stem and unilateral strobilus, poses a problem. Perhaps the radial symmetry is primitive and S. *Dregei* should be placed apart from S. *echinata* and S. *proxima*, or perhaps, as the chart implies, it may be derived from species with dorsiventral leafy stems.

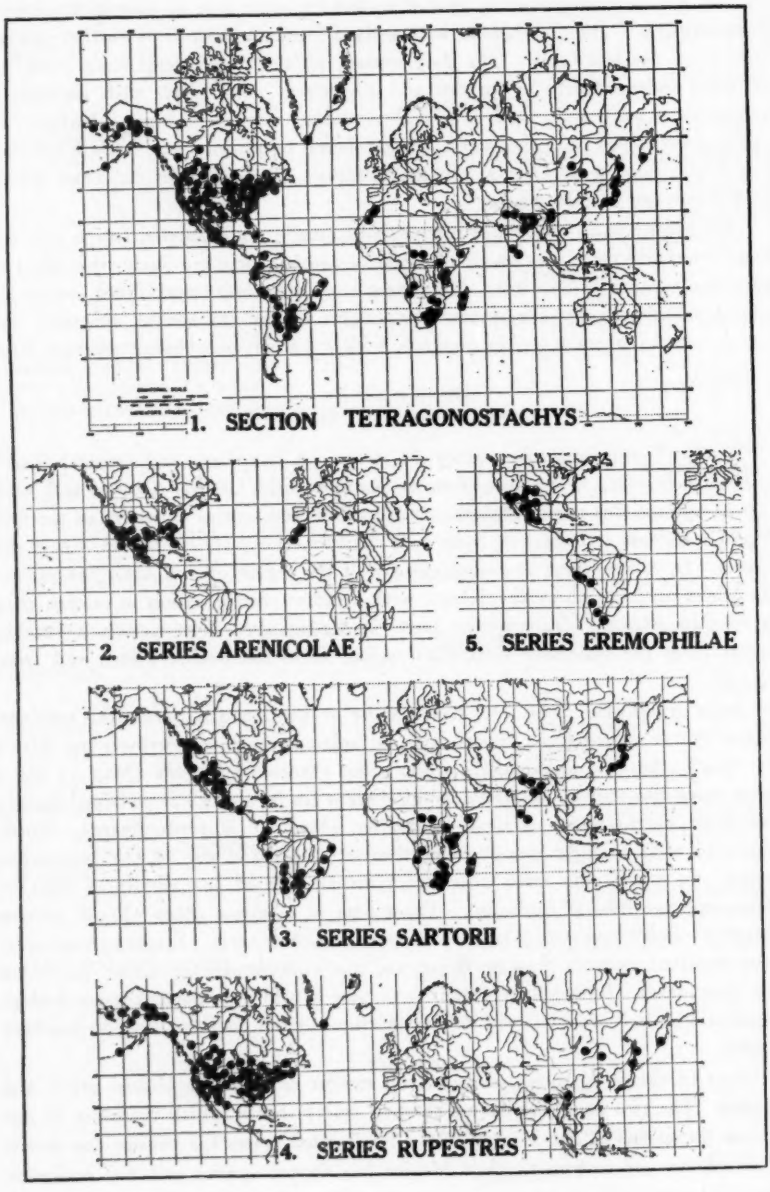
The evolutionary relation of the species is usually not known although in a few cases it is fairly clear that one is ancestral to another, or more likely, that the two have had a common ancestor. Within each series the most specialized species are considered advanced. The species that exhibit few if any special structures and which may have characters in common with a less advanced series are considered primitive.

Geography and Ecology

Section *Tetragonostachys* (Map 1) occurs in temperate and tropical North and South America; it is absent from the Amazon basin, Central America and, with few exceptions, the colder regions. Its distribution is not as extensive in the Old World. In Asia it occurs in India and the Himalayan region and in Japan and Siberia. In Africa there is a single species in the region of the Atlas Mountains; the others occur south of the Sahara, with a better representation in eastern than in western Africa. Three species grow in Madagascar. The section is notably absent from the Malaysian-Australian region, from the Pacific Ocean and from Eurasia.

Series *Arenicolae* (Map 2) extends more or less laterally across the southern United States and adjacent Mexico with an isolated species in northwestern Africa —a distribution not unlike that of the genus *Platanus*. *Sartorii* (Map 3) has a range much like that of the whole section except for its absence from boreal regions and from northwestern Africa. *Rupestres* (Map 4) is predominantly North American with a single species in northeastern Asia and one in the Himalayan region. It is the only series that has a distribution of any extent in areas of Pleistocene continental glaciation. The ranges of S. *densa* (Map 43), S. *sibirica* (Map 47) and S. *rupestris* (Map 42) are partly in these areas. S. *rupestris* occupies more glaciated territory than the others and it is undoubtedly significant that there it is apogamous. *Eremophilae* (Map 5) is New World with essentially an Andean distribution. It is absent in the American tropics from northern Peru to southern Mexico.

Most of the forty-three species of the section grow in the United States and Mexico. The two countries have a total of thirty species which represent all but two of the species of the New World. The United States has twenty-one species of which ten are endemics, while Mexico has sixteen species and five endemics. The southwestern United States—Texas to southern California—is the richest area


1. SECTION TETRAGONOSTACHYS
2. SERIES ARENICOLAE
5. SERIES EREMOPHILAE
3. SERIES SARTORII
4. SERIES RUPESTRES

with a total of seventeen species. Ten species, four of them endemic, grow in California and eight species in Texas. There are three species in Canada, two in Alaska, one in Cuba, one in Guatemala and four in South America. Africa has five species, four of them endemics, Madagascar three endemic species, India and the Himalayan area three species, two endemic, and northeastern Asia two species, one of them endemic.

Most of the species have continuous ranges, minor discontinuities probably being due to insufficient collecting. The important and apparently authentic examples of discontinuous range are the following. Both S. *Sellowii* (Map 17) and S. *Sartorii* (Map 18) are disjunct between Mexico and northern South America and the former species has an isolated station in Cuba. S. *peruviana* (Map 52) is similar but the disjunction is wider. S. *Wightii* (Map 19) grows in southern India and Ceylon and in Africa; S. *rupestris* (Map 42) has an isolated station in southern Greenland.

Most of the species of each series are allopatric in their distribution and, with two exceptions, the relatively few cases of sympatric species are ecologically separated. The examples I know in which two species of the same series actually grow together are S. *densa* and S. *rupestris* in Canada and S. *peruviana* and S. *arizonica* in Texas. The latter pair may sometimes grow in the same mat.

There are two important ecological features of the species. They are mostly plants of dry habitats and they usually do not thrive in the presence of other plants. Consequently they are most abundant in regions of moderate rainfall, or in locally dry habitats in moist areas, and they grow in rocky, gravelly or sandy places, or on cliffs or barren soil where there is a minimum of other vegetation. One species, S. *oregana*, is usually an epiphyte and another, S. *extensa*, occasionally is. Many of the species grow in acid soil or on acid rocks; a few of them will also grow on basic rocks; a single species, S. *Wrightii*, is definitely a calciphile. There is little evidence that they are important pioneers, being notably few in glaciated areas and in rocky places recently disturbed by fire or lumbering. Rather their chief role seems to be to fill the niche of locally transient but regionally permanent open, xeric habitats.

The plants are not especially adapted either for the prevention of water loss or for its storage. The minor adaptations that are present in the form of fleshy and cutinized leaves are not sufficient to prevent frequent drying. The ability to survive desiccation undoubtedly resides in unusual physical and chemical properties of the cell contents. The extensive network of roots, borne close to the surface, enables the plants to utilize rapidly even small amounts of moisture. The species probably can grow in relatively moist places, as a few of them do, but because of their inability to compete with other plants, these habitats are not often available. They are restricted to the open habitats, which in a given area are usually the most xeric, where their special ability to survive desiccation allows them to be successful.

DISTRIBUTION MAPS

A solid dot is used on the maps to indicate the location of a collection seen; in a few cases a circle is used to represent a specimen from a general region. In S. *arenicola*, half-dots are used to represent intermediates between the subspecies. Literature records, indicated by an X, have been used when they significantly augment the range and when there is no doubt about the identity of the species. Except for S. *Balansae*, all of the literature records have been taken from the various papers of A. H. G. Alston.

ACKNOWLEDGMENTS

I am indebted to the curators of the herbaria of the following institutions for the generous loan of material. Botanisches Museum, Berlin-Dahlem, British Museum (Natural History), Chicago Natural History Museum, Gray Herbarium, Department of Botany, University of Minnesota, New York Botanical Garden, Muséum National d'Histoire Naturelle, Paris, United States National Herbarium and Department of Botany of Yale University. The abbreviations for these and other herbaria are taken from Index Herbariorum, part I (Regnum Vegetabile, vol. 2).

I wish to thank Mr. A. H. G. Alston and Mr. J. A. Crabbe of the British Museum, Mr. F. Ballard of Kew, Mme. Tardieu-Blot of Paris, Dr. H. Reimers of Berlin, and Mr. C. V. Morton of the United States National Herbarium for courtesies extended during the course of this study.

SYSTEMATIC ACCOUNT

SYNOPSIS OF SELAGINELLA SUBGENUS SELAGINELLA[16]

SELAGINELLA Beauv. Prod. Aethog. 101. 1805, conserved name. Type species: *Selaginella selaginoides* (L.) Link.

SUBGENUS SELAGINELLA (Section *Homoeophyllae* Spring, in Mart. Fl. Bras. 1:118. 1840. *Homotropae* A. Br. Ind. Sem. Hort. Bot. Berol. 1857: Append. 11. 1857, without rank. Subgenus *Euselaginella* Warb. Monsunia 1:100. 1900. Subgenus *Homoeophyllum* (Spring) Hieron. in Engl. & Prantl, Nat. Pflanz. 1^4:669. 1901.). Sporophylls uniform or similar, leaves uniform or gradually dimorphic. Type species: *Selaginella selaginoides* (L.) Link.

SECTION SELAGINELLA (*Cylindrostachyae* A. Br. loc. cit., without rank. Section *Cylindrostachys* (A. Br.) Hieron. loc. cit.). Strobilus cylindrical, leaves spirally arranged. Type species: *Selaginella selaginoides* (L.) Link. SPECIES: 1. S. *selaginoides* (L.) Link, 2. S. *deflexa* Brack.

[16] Partly adapted from Walton & Alston, in Verdoorn, Man. Pterid. 503. 1938.

SECTION **Tetrastichus** (A. Br.) Tryon, stat. nov. (*Tetrastichae* A. Br. loc. cit., without rank). Strobilus tetragonous, at least the lower leaves decussate. Type species: *Selaginella pumila* (Schlecht.) Spring. SPECIES: 1. S. *pygmaea* (Kaulf.) Alston (S. *pumila* (Schlecht.) Spring), 2. S. *gracillima* (Kze.) Alston (S. *Preissiana* Spring), 3. S. *uliginosa* (Labil.) Spring.

SECTION TETRAGONOSTACHYS (A. Br.) Hieron. loc. cit. (*Tetragonostachyae* A. Br. loc. cit., without rank). Strobilus tetragonous, leaves spirally arranged. Type species: *Selaginella rupestris* (L.) Spring.

SERIES **Arenicolae** Tryon. Type species: *Selaginella arenicola* Underw. SPECIES: 1. S. *rupincola* Underw., 1a. S. × *neomexicana* Maxon, 2. S. *Bigelovii* Underw., 3. S. *arenicola* Underw., 3a. ssp. **Riddellii** (Van Eselt.) Tryon, 3b. ssp. **arenicola**, 3c. ssp. **acanthonota** (Underw.) Tryon, 4. S. *Balansae* (A. Br.) Hieron., 5. S. *Weatherbiana* Tryon, 6. S. *viridissima* Weath., 7. S. *tortipila* A. Br.

SERIES **Sartorii** Tryon. Type species: *Selaginella Sartorii* Hieron. SPECIES: 8. S. *Sellowii* Hieron., 9. S. *Sartorii* Hieron., 10. S. *Wightii* Hieron., 10a. var. **Wightii**, 10b. var. *Phillipsiana*, 11. S. *cinerascens* A. A. Eaton, 12. S. *Arsenei* Weath., 13. S. *macrathera* Weath., 14. S. *shakotanensis* (Franch. ex Takeda) Miyabe & Kudo, 15. S. *Wallacei* Hieron., 16. S. *mutica* D. C. Eaton ex Underw., 16a. var. *limitanea* Weath., 16b. var. **mutica**, 17. S. *extensa* Underw., 18. S. *Wrightii* Hieron., 19. S. *Steyermarkii* Alston, 20. S. *Hansenii* Hieron., 21. S. **carinata** Tryon, 22. S. **indica** (Milde) Tryon, 23. S. *njamnjamensis* Hieron., 24. S. *caffrorum* (Milde) Hieron., 25. S. *echinata* Baker, 26. S. *nivea* Alston, 27. S. **proxima** Tryon, 28. S. *Dregei* (Presl) Hieron.

SERIES **Rupestres** Tryon. Type species: *Selaginella rupestris* (L.) Spring. SPECIES: 29. S. *Vardei* Lév., 30. S. *oregana* D. C. Eaton, 31. S. *Underwoodii* Hieron., 32. S. *rupestris* (L.) Spring, 33. S. *densa* Rydb., 33a. var. **scopulorum** (Maxon) Tryon, 33b. var. **densa**, 33c. var. **Standleyi** (Maxon) Tryon, 34. S. *sibirica* (Milde) Hieron., 35. S. *Watsonii* Underw., 36. S. *utahensis* Flowers, 37. S. *leucobryoides* Maxon, 38. S. *asprella* Maxon.

SERIES **Eremophilae** Tryon. Type species: *Selaginella eremophila* Maxon. SPECIES: 39. S. *peruviana* (Milde) Hieron., 40. S. *arizonica* Maxon, 41. S. *eremophila* Maxon, 42. S. *Parishii* Underw., 43. S. *Landii* Greenm. & Pfeiff.

KEY TO THE SERIES OF SECTION TETRAGONOSTACHYS

a. Stems erect or ascendent with rhizophores produced only at or near the base, rarely one or a few stems of a group prostrate with rhizophores produced nearly throughout; subterranean rhizomes or ground-level stolons or basal branch buds present ..... Series *Arenicolae*, p. 18

a. Stems prostrate to decumbent, or irregularly ascendent, with rhizophores produced at or near the apex, at least of the primary stems (the branches may rarely be erect), or epiphytic and long-pendent with rhizophores produced only at the base; rhizomes and stolons absent, basal branch buds rarely and irregularly present. b.

b. Leaves with the base abruptly adnate and distinct from the stem in color[17] on all sides of the stem, or especially on the branches, those on the main stem rarely decurrent ..... Series *Sartorii*, p. 31

b. Leaves with the base decurrent on all sides of the stem[17] or at least those on the underside strongly decurrent. c.

c. Upper leaves with the base usually decurrent; leafy stem radially symmetrical to definitely dorsiventral, the zone of green leaves[18] about equal on all sides of the stem; branch tips straight or slightly curled in the dormant condition ..... Series *Rupestres*, p. 58

c. Upper leaves with the base abruptly adnate, distinct from the stem in color (rarely a distinct stem-ridge may be present); leafy stem strongly dorsiventral, the zone of green leaves[18] well developed on the upper side of the stem, very short to absent on the under side; branch tips involute in the dormant condition ..... Series *Eremophilae*, p. 76

SERIES **Arenicolae** Tryon, ser. nov.

Rhizomata vel gemmae brevia simplicia ad bases caulium aeriorum hae saepe stolones producentes praesentia. Caules erecti vel ascendentes. Apices ramorum recti vel leviter curvati statu inerte. Caules frondosi radialiter symmetricales. Folia base decurrente vel abrupte adnata cum caule distincta colore. Typus: *Selaginella arenicola* Underw.

Plants terrestrial; rhizomes present, their leaves different from those of the aerial stem, thinner, with shorter setae, generally broader, with shorter cilia, with a less-developed dorsal groove, the living ones pale tan to a very pale green, *or* short, simple buds present at the base of the aerial stems, these sometimes elongated to form stolons, *or* both rhizomes and basal buds present. Stems erect or ascendent, with rhizophores produced only at or near the base, rarely one or a few stems (especially in S. *rupincola*) prostrate with rhizophores produced generally throughout; stems short to moderately so, forming distinct groups or in the species with

[17] To be observed between the first and third branches back from the apex of the stem.
[18] This character may be obscured by death of the leaves during a long dormancy.

rhizomes usually forming tall, loose mats. Branches short to moderately long, usually remote, discrete or intricate; branch tips straight or slightly curved in the dormant state. Leafy stems radially symmetrical, the leaves equal in position, length, shape and texture on all sides of the same portion of the stem, rarely slightly dorsiventral in position on prostrate stems; zone of green leaves equal on all sides of the stem or rarely slightly longer on the upper side. Leaves with the base abruptly adnate and distinct from the stem in color, to decurrent; dorsal groove evident from base to apex, or in S. *tortipila* absent or poorly developed; setae, if present, relatively straight and stout, without a modified tip, persistent, or in S. *tortipila* with a filiform, tortuous, usually deciduous tip.

Arenicolae is a homogeneous series although the species are quite distinct and show considerable diversity. The species are held together by the characters of the limited growth of the aerial branches and the rhizome or bud growth at the base of the branches.

The leaf-base which is such an important character in the other series is variable here. In S. *rupincola* and S. *Bigelovii*, the only two species that show a close affinity, the leaf-base is abruptly adnate to the stem and distinct in color. In S. *Balansae*, S. *Weatherbiana* and S. *viridissima* it is decurrent toward the base of the branches and tends to be abruptly adnate toward the tip. In S. *arenicola* and S. *tortipila* the leaf-bases are decurrent. The least specialized species appear to be S. *rupincola* and S. *arenicola*, while the most specialized, those with modified setae, are certainly S. *tortipila* and S. *viridissima*. No species shows an evident relation to a species of any other series.

KEY TO SPECIES

a. Leaves with the base abruptly adnate and distinct from the stem in color on all branches. b.

b. Rhizomes absent; cilia of the leaves of a branch-system usually predominantly or entirely piliform, about ¼ as long as the width of the blade or longer, rarely only a few piliform; leaf-apex flat to rounded. Arizona to Texas, Tamaulipas to Sonora and southward....1. S. *rupincola*, p. 20

b. Rhizomes present; cilia of the leaves of a branch system usually predominantly or entirely dentiform, about ⅛ to 1/16 as long as the width of the blade, rarely some or most piliform and longer; leaf-apex usually carinate to broadly rounded. California and Baja California.....2. S. *Bigelovii*, p. 22

a. All or at least the basal leaves of the aerial branches and of the rhizomes (when present) with the base decurrent. c.

c. Setae of the leaves stout, relatively straight, without a modified tip, persistent, or setae absent; dorsal groove evident from the base to the apex. d.

d. Leaves setate. e.

e. Rhizomes absent, short stolons occasionally present. Texas to Florida and North Carolina ..... 3. *S. arenicola*, p. 23

e. Rhizomes present. f.

f. Leaf-apex flat to slightly rounded; setae tawny to whitish. Northwestern Africa ..... 4. *S. Balansae*, p. 27

f. Leaf-apex strongly carinate; setae lutescent to greenish-white. New Mexico and Colorado ..... 5. *S. Weatherbiana*, p. 28

d. Leaves muticous ..... 6. *S. viridissima*, p. 28

c. Setae of the leaves usually with a long, filiform, tortuous, often partly or wholly deciduous tip, rarely the tip only irregularly flexuous, or the setae without a modified tip; dorsal groove absent or developed only in the mid-portion of the blade, rarely moderately developed but not extending to the base or apex ..... 7. *S. tortipila*, p. 29

1. SELAGINELLA RUPINCOLA Underw. in Bull. Torr. Bot. Club 25:129. 1898. (Lectotype: *Wooton 124* NY! marked by Underwood as type although he did not cite it as such. Paratypes: *Palmer 92* K; *Toumey* US!; *Wright 2116* NY!, US! cited by Underwood as *2106*). Figs. 1, 2. Map 6.

Selaginella Chrismarii Hieron. in Hedwigia 39:299. 1900, as *Chrismari*. (Holotype: *von Chrismar* B!; *Purpus 3156* F, GH, MO, US is identical).

Selaginella Chrismarii var. *Karwinskyana* Hieron. in Hedwigia 39:300. 1900. (Lectotype: *Palmer 554* B! chosen because of its wide distribution although at least at GH and US it is mixed with *S. peruviana*. Paratypes: *Karwinsky* B!; *Schaffner 11* B!).

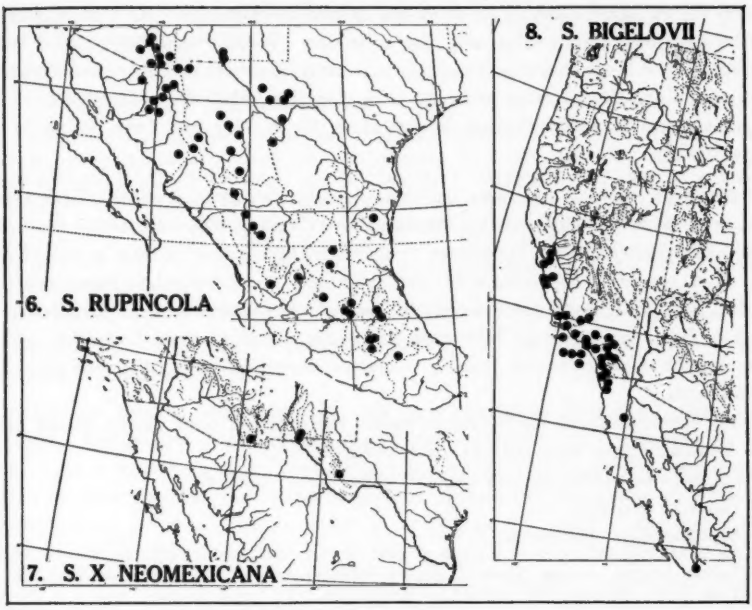
Selaginella Chrismarii var. *Neeana* Hieron. in Hedwigia 39:300. 1900. (Holotype: *Née* B!).

Selaginella rupestris (L.) Spring var. *rupincola* (Underw.) Clute, Fern Allies, 142. 1905.

Rhizomes absent; aerial branches with buds present at their base, erect or ascendent, sometimes decumbent at the base, rarely one or some of the branches of a plant prostrate. Leaves with the base abruptly adnate, distinct from the stem in color; margins ciliate, the cilia usually piliform, ¼ as long as the width of the blade or longer, rarely some or most leaves with the cilia predominantly dentiform and shorter; apex flat to rounded to rarely carinate; setae milk-white and opaque or sometimes with a greenish-lutescent base, to whitish-lutescent and translucent. Megaspores rugose to rugose-reticulate, rarely nearly smooth on the outer face, pale orange.

S. rupincola is closely related only to *S. Bigelovii;* the two may be separated by the characters in the key. The long spreading cilia on the leaves are most characteristic but infrequently they may be rather short. In a very few specimens that I have seen the stems are prostrate but these may be distinguished from species of other series by the basal buds. A park supervisor in Arizona informed me that in times of drought this plant was browsed by deer.

Dry open places, on ledges and in crevices of cliffs, on rocky slopes or in talus, or in gravel, usually from 1000 to 2000 m., rarely up to 3500 m. It is apparently confined to igneous rocks.



Texas to Arizona, south to Puebla.

Representative specimens:

UNITED STATES. TEXAS: *Cory 48388* (GH); *Warnock 614* (GH, US), *20893* (F, MO). NEW MEXICO: Organ Mountains, Dona Ana Co., 5800 ft. July 10, 1897, *Wooton 124* (K, MO, NY, US); *Wright 2116* (sometimes as *2106*) (GH, K, MO, NY, US). ARIZONA: *Ferriss 26* (NY, US); *Maguire 10021* (GH, US); Santa Catalina Mountains, April 3, 1894, *Toumey* (US); *R. M. & A. F. Tryon 5050* (ARIZ, B, BM, DS, F, FI, GH, K, MICH, MO, NY, P, RM, UC, US), *5051* (CU, GH, MIN, MO, PH, POM, US, WS). MEXICO. *Née* (B); 1827, *Karwinsky* (B). COAHUILA: *Johnston & Muller 307* (GH). CHIHUAHUA: sw. Chihuahua, *E. Palmer 92* in 1885 (GH, MO, US); *E. Palmer 38* in 1908 (B, F, GH, MO, US). SONORA: *Gentry 1194* (F, GH, MO, US); *Wiggins & Rollins 450* (GH, MO, NY, US). TAMAULIPAS: *Bartlett 10529* (F, US). DURANGO: city of Durango and vicinity, *E. Palmer 554* in 1896 (B, BM, F, GH, MO, US); *E. Palmer 485* in 1906 (BM, F, GH, MO, US). GUANAJUATO: Guanajuato, 1848, *von Chrismar* (B). JALISCO: Nov. 16, 1930, *M. E. Jones* (BM, GH, MO, US). DISTRITO FEDERAL: *Schaffner 11* (B, GH, US). PUEBLA: *Purpus 3156* (BM, F, GH, MO, US).

1a. SELAGINELLA × NEOMEXICANA Maxon, in Smiths. Misc. Coll. 72[5]:2. 1920, as *S. neomexicana*. (= *S. mutica* × *rupincola*). (Holotype: *Wooton* in 1909 US! fragment GH!. Paratypes: *Wooton* in 1902 US!, in 1904 US!, in 1907 US! fragment MO!). Map 7.

The recognition of *S.* × *neomexicana* as a putative hybrid is based on its abortive spores and intermediate morphological characters. The sporangia and

spores are variously abortive in all of the specimens examined. No mature megaspores have been seen and in only one collection (*Wooton* in 1904) have I seen microspores of a size that might indicate maturity. These are probably also abortive, however, since they average some 22 μ in diameter, while the microspores of S. *rupincola* and S. *mutica*[19] range in size from 38 to 64 μ and from 30 to 53 μ respectively.

Although abortive sporangia and spores might be due to a number of causes, specimens with this character are intermediate in various degrees between the two proposed parental species. The erect to ascendent branches with buds at their base are characters of S. *rupincola* while the commonly linear-lanceolate leaves usually with a strongly carinate apex suggest S. *mutica*. Most specimens are rather intermediate but some, such as *Wherry* in 1925, are rather close to S. *mutica* while others, such as *Wooton* on January 9 and on September 28, 1909, are close to S. *rupincola*.

The distribution of the hybrid is within the range of both parent species and it is known to grow with both at some localities.

On open or shaded igneous rocks at about 1000–2000 m.

Texas to Arizona.

Representative specimens:

United States. texas: *Slater 2, 3* (US); *Knoblock 5557* (US); *Soxman 351* (US); April 26, 1925, *Wherry* (US); *Hinckley 3404* (GH, US). new mexico: March 3, 1907, *Wooton* (F, MO, US); Organ Mountains, Dona Ana Co., 6000 ft., Jan. 9, 1909, *Wooton* (GH, US); Sept. 28, 1902, *Wooton* (NY, US); Sept. 11, 1904, *Wooton* (US). arizona: Paradise, Cochise Co., 1904, *Ferriss* (GH, US).

2. Selaginella Bigelovii Underw. in Bull. Torr. Bot. Club 25:130. 1898. (Holotype: *Bigelow* NY!. Paratypes: *Coville & Funston 101* NY!; *Henshaw* NY! US!; *Parish & Parish 671* NY!; *Underwood* NY!). Fig. 3. Map 8.

Rhizomes widely creeping; aerial branches with buds often present at their base, erect, rarely some decumbent at the base. Leaves with the base abruptly adnate, distinct from the stem in color; margins ciliate, the cilia usually dentiform, about $\frac{1}{8}$ to $\frac{1}{6}$ as long as the width of the blade, less often some or most of the leaves with the cilia piliform and longer; apex strongly carinate to broadly rounded, or predominantly so; setae usually milk-white and opaque, to whitish, lutescent- or greenish-white, translucent. Megaspores rugose to rugose-reticulate, rarely nearly smooth on the outer face, lemon-yellow to pale orange.

S. *Bigelovii* is closely related to S. *rupincola* from which it differs by the presence of rhizomes in addition to the less important leaf characters mentioned in the key. It has been reported to be browsed by cattle in times of drought.[20]

This species usually grows in open places, on serpentine, sandstone or igneous rocks, in crevices or shallow depressions, on cliffs, at the base of boulders or in

[19] Tryon, A. F. in Ann. Mo. Bot. Gard. 36:418, 419. 1949:
[20] Wiggins, I. L. in Amer. Fern Jour. 22:15. 1932.

gravelly soil, less often in shaded or moist situations or in clay soil; it occurs from about sea level up to 2000 m.

California and Baja California.

Representative specimens:

UNITED STATES. CALIFORNIA: *Abrams 3126* (GH, MO, NY), *3402* (F, GH, MO, NY, US); Lt. Whipple's Exped., March 16, 1854, *Bigelow* (GH, NY, US, YU); *Clokey 5165* (F, GH, NY); *Coville & Funston 101* (GH, NY, US); *Fosberg 697* (F, MO, NY, US); *Heller 7276* (GH, MO, NY, US), *7610* (F, GH, MO, NY, US), *8604* (F, GH, MO, NY, US); April 3, 1893, *Henshaw* (NY, US); *Moxley 876* (F, GH, NY, US); *E. Palmer 434* in 1875 (F, MO, NY); *Parish & Parish 671* (F, NY); *R. M. & A. F. Tryon 5053* (BM, MO, NY, P), *5054* (F, K, MO, UC), *5056* (B, GH, MO, US); Jan. 1889, *Underwood* (NY).

MEXICO. BAJA CALIFORNIA: *Ferris 8470* (NY, US); *Wiggins 4212* (F, GH, NY, US).

3. SELAGINELLA ARENICOLA Underw. in Bull. Torr. Bot. Club 25:541. 1898, based on S. *arenaria* Underw. Map 9.

Rhizomes absent; aerial branches with buds present at their base, which are sometimes elongated to form stolons, strictly erect, ascendent to decumbent at the base. Leaves with the base decurrent, blending into the stem in color or sometimes rather abruptly decurrent on the apical portion of the stem; margins rarely eciliate, usually ciliate, the cilia piliform, about ¼ as long as the width of the blade, less often shorter or dentiform; apex nearly flat to carinate; setae usually milk-white to tawny and opaque, rarely whitish with a lutescent base and translucent. Megaspores rugose, rugose-reticulate to rugose-tuberculate on the commissural face, less prominently marked to smooth on the outer face, white to pale orange.

The three subspecies differ in characters of essentially specific value but there are too many intermediates to allow them full recognition. These characters are those mentioned in the key to subspecies. In addition, the subspecies also tend to differ in various leaf characters but these are too variable within each subspecies to be of taxonomic value. Ssp. *Riddellii* has the longest leaf-base and ssp. *acanthonota* has the shortest; ssp. *acanthonota* has the longest setae and ssp. *Riddellii* the shortest; ssp. *acanthonota* has the stoutest leafy stem with the most leaves; ssp. *Riddellii* has the most slender stem with the fewest leaves; and ssp. *acanthonota* has the most cilia on a leaf while ssp. *Riddellii* has the fewest. Subspecies *arenicola* occupies an intermediate position in the range of variability of all of these characters.

Subspecies *Riddellii* is evidently the most primitive of the subspecies. The manner of death of the strobilus is the same as that in all other species of the series and its spores are less distinctive. Ssp. *acanthonota*, with aerial rhizophores, is the most advanced. S. *arenicola* differs from S. *rupincola*, the other member of the series that lacks rhizomes, in having the base of the leaves, at least on the basal portions of the stems, decurrent rather than abruptly adnate.

It grows in open habitats or in light shade, in sand or in weathered soil pockets of acidic rocks. It probably has considerable ability as a colonizer; at least I have seen it in Florida growing on the graded sides of relatively recent roads.

North Carolina to Texas.

KEY TO SUBSPECIES

a. Aerial branches erect; all rhizophores subterranean, branched into roots near the base. b.
  b. Basal sporophylls of a strobilus die after the leaves beneath the strobilus; outer face of the megaspores usually rugose ..... 3a. ssp. *Riddellii*, p. 24
  b. Basal sporophylls of a strobilus die before the leaves beneath the strobilus; outer face of the megaspores usually smooth ..... 3b. ssp. *arenicola*, p. 26
a. Aerial branches erect to decumbent at the base; all or many of the rhizophores aerial and unbranched toward the base; basal sporophylls of a strobilus die before the leaves beneath the strobilus; outer face of the megaspores usually smooth ..... 3c. ssp. *acanthonota*, p. 26

3a. SELAGINELLA ARENICOLA ssp. **Riddellii** (Van Eselt.) Tryon, comb. nov. Map 10.

Selaginella Riddellii Van Eselt. in Contrib. U. S. Nat. Herb. 20:162. 1918. (Holotype: *Thurow 7* US!. Paratypes: *Drummond 352* NY!; *Holmes & Fetherolf* US!; *Jermy 342* MO!, US!; *Lindheimer 76* MO!; *Long* in 1900 NY!, in 1901 NY!; *Plank* on Aug. 10, 1892 NY!, on Aug. 18, 1892 NY!; *Reverchon 1632* MO!, NY!, US!; *Riddell 16* NY!; *Thurow* US!, *8* US!).

Basal buds sometimes elongated to form stolons; aerial branches erect; rhizophores subterranean, branched into roots near their base. Strobilus usually borne on a long leafy branch, often with vegetative apical growth; basal sporophylls dying after the leaves beneath the strobilus. Megaspores with the outer face usually rugose to rugose-reticulate, rarely smooth.

The following material is intermediate between ssp. *Riddellii* and ssp. *arenicola* (Map 10): LOUISIANA: *Dorman* in 1935 (GH, US); *Wherry* in 1937 (US). ALABAMA: *Harper 37* (GH, MO, NY, US), *3116* (MO, NY, US); *Wolf* in 1933 (US); *Leeds* in 1934 (NY); *Gattman* in 1938 (F). GEORGIA: *Harper 1800* (F, GH, MO, NY, US); *Pyron & McVaugh 3051* (US); *Duncan 8683* (MO).

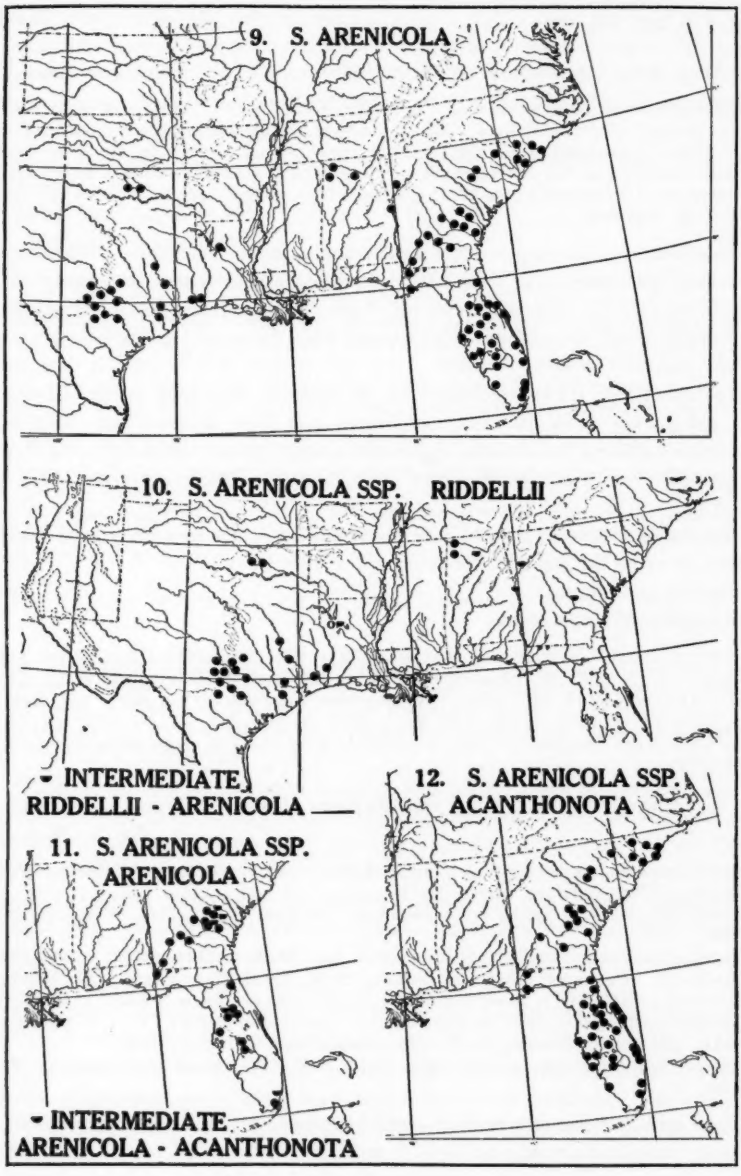
All of the material cited above from Alabama is from Eight-mile Creek and St. Bernard, Cullman Co., and has most of the megasporangia abortive. This is suggestive of hybridization, perhaps with S. *rupestris* which is known from Franklin Co., but it may be due to other causes.

Subspecies *Riddellii* grows in open areas or in open woods, in sand or in crevices or shallow depressions of granite, sandstone or conglomerate outcrops, or at the base of boulders.

Alabama to Oklahoma and Texas.

Representative specimens:

UNITED STATES. ALABAMA: *Harper 3403* (GH, MO, NY, US), *3762* (GH, MO, NY, US). LOUISIANA: Red River, *Hale* (GH, US). OKLAHOMA: 1928, *Draper & Gould* (US); *Waterfall 6426a* (GH). TEXAS: *Cutler 3220* (GH, MO); *Drummond 352* (GH, NY, US); Jan. 1903, *Holmes & Fetherolf* (US); *Jermy 342* (MO, US); *Lindheimer 76* (GH, MO, US); March, 1900, *W. H. Long* (NY); Feb. 1901, *W. H. Long* (NY); *E. J. Palmer 9540* (MO, US), *13411* (MO, US), *33364* (GH, MO); Aug. 10, 1892, *Plank* (NY); Aug. 18, 1892, *Plank* (NY); *Reverchon 1632* (F, GH, MO, NY, US); *Riddell 16* (NY);


9. S. ARENICOLA
10. S. ARENICOLA SSP. RIDDELLII
- INTERMEDIATE RIDDELLII - ARENICOLA
11. S. ARENICOLA SSP. ARENICOLA
12. S. ARENICOLA SSP. ACANTHONOTA
- INTERMEDIATE ARENICOLA - ACANTHONOTA

Oct. 26, 1915, *Thurow* (GH, NY, US); near Prairie View, Waller Co., Jan. 3, 1911, *Thurow 7* (US); *Thurow 8* (US); *R. M. & A. F. Tryon 5030* (B, GH, MO, US), *5033* (BM, F, P, MO, NY, US).

3b. SELAGINELLA ARENICOLA ssp. **arenicola.** Fig. 4. Map 11.

Selaginella arenaria Underw. in Bull. Torr. Bot. Club 25:129. 1898, not *Baker 1883*. (Lectotype: *Underwood 1355* NY! was marked by Maxon as type as to six of the specimens (now marked x); the other specimens and all of those on the sheet of the same collection at US are intermediate between ssp. *arenicola* and ssp. *acanthonota*. Paratypes: *Underwood 1355a* NY!; *Chapman* NY!. *Nash 1449* is excluded as a type, it is ssp. *acanthonota*).

Basal buds not forming stolons; aerial branches erect; rhizophores subterranean, branching into roots near their base. Strobilus usually borne on a long leafy branch, very rarely with vegetative apical growth; basal sporophylls dying before the leaves beneath the strobilus. Megaspores with the outer face smooth to rarely rugose.

Specimens that are intermediate with ssp. *Riddellii* have been mentioned under that subspecies. The following specimens are those intermediate with ssp. *acanthonota* (Map 11): GEORGIA: *Pyron & McVaugh 3101* (MO, US), *3114* (US), *3175a* (US). FLORIDA: *A. A. Eaton* in 1903 (US); *Underwood 1355* (NY in part, US).

Subspecies *arenicola* grows in open places among shrubs in white sand or rarely in crevices or on flat exposures of sandstone or granite.

Georgia and Florida.

Representative specimens:

UNITED STATES. GEORGIA: *A. H. Curtiss 6714* (GH, MO, NY, US); *Harper 1854* (MO, NY, US), *1860* (F, GH, MO, NY, US); *Pyron & McVaugh 3048* (US), *3175* (MO, US); *Tracy 3510* (MO, US). FLORIDA: 1840, *Chapman* (NY); July, 1934, *Fennell* (NY, US); *Tryon 5014* (B, BM, GH, MO), *5016* (F, MO, NY, P, US), *5017* (K, MO, UC); Eustis, Lake Co., Jan. 14, 1891, *Underwood 1355* (NY, as to specimens marked x), *1355a* (NY).

3c. SELAGINELLA ARENICOLA ssp. **acanthonota** (Underw.) Tryon, comb. nov. Fig. 5. Map 12.

Selaginella acanthonota Underw. in Torreya 2:172. 1902. (Holotype: *Williamson* NY! fragment US!. Paratype: *Curtis* NY!).

Selaginella rupestris (L.) Spring var. *acanthonota* (Underw.) Clute, Fern Allies, 142, 264. 1905.

Selaginella funiformis Van Eselt. in Proc. Biol. Soc. Wash. 30:161. 1917. (Holotype: *Mohr* US!. Paratypes: *Chapman*, Biltmore Herb. *3432b* US!; *Huger* NY!; *Small & Carter 1013* GH!, NY!; *Small & Wilson 1762* NY!; *Small, Carter & Small 3349* NY!).

Selaginella humifusa Van Eselt. in Contrib. U. S. Nat. Herb. 20:165. 1918, not Hieron. 1911. (Holotype: *Nash 1449* US!. Paratypes: *Eaton* GH!; *Rapp* US!).

Selaginella floridana Maxon in Amer. Fern Jour. 11:1. 1921, based on S. *humifusa* Van Eselt.

Basal buds not forming stolons; aerial branches erect to usually decumbent at the base; rhizophores mostly or entirely aerial and unbranched toward their base. Strobilus borne on a very short to moderately long leafy branch, without vegetative

apical growth; basal sporophylls dying before the leaves beneath the strobilus. Megaspores with the outer face smooth.

Specimens intermediate with ssp. *arenicola* have been discussed under that subspecies. In the several leaf characters mentioned in the discussion of *S. arenicola* the ones characteristic of ssp. *acanthonota* tend to be more distinctive in the northeastern portion of the range, particularly in North Carolina.

Ssp. *acanthonota* grows in open places among shrubs in white sand, rarely on sandstone.

North Carolina to Florida.

Representative specimens:

UNITED STATES. NORTH CAROLINA: *Blake 11481A* (GH, US); *Curtis* (NY); *Heller 14101* (F, MO); Wilmington, July, 1892, *Williamson* (NY, US). SOUTH CAROLINA: *Hermann 10008* (F, GH, MO, NY, US). GEORGIA: *Harper 1852* (F, GH, MO, NY, US), *1957* (F, GH, MO, NY, US), *1987* (GH, MO, NY, US); *Hermann 10128* (F, NY, US); *Tryon 5027* (B, BM, GH, K, MO, P, UC, US). FLORIDA: *Chapman* (Biltmore Herb. 3432b) (GH, NY, US); Nov. & Dec. 1903, *A. A. Eaton* (F, GH); *Foster et al.* (Pl. Exsicc. Gray. 1305) (GH, MO, US); *Harper 10* (F, MO, NY, US), *16* (F, GH, MO, NY, US), *17* (F, MO, NY, US); Jan.-Feb., 1902, *Huger* (NY, US); Carabelle, March 15, 1898, *Mohr* (NY, US); vicinity of Eustis, Lake Co., July 16–31, 1894, *Nash 1449* (F, GH, MO, NY, US); *E. Palmer 660* in 1874 (GH, MO, US); Sept. 1902, *S. Rapp* (NY, US); *Small & Carter 1013* (F, GH, NY, US); *Small, Carter & Small 3349* (NY, US); *Small & Wilson 1762* (NY, US); *Tracy 7554* (F, GH, MO, NY, US); *Tryon 5012* (BM, DS, GH, MIN, MO), *5021* (B, BM, F, GH, K, MO, NY, P, UC, US), *5026* (ARIZ, MICH, MO, RM, US), *5093* (CU, FLAS, MO, PH, POM, US, WS).

4. SELAGINELLA BALANSAE (A. Br.) Hieron. in Hedwigia 39:318. 1900.

Fig. 6. Map 13.

Selaginella rupestris (L.) Spring var. *Balansae* A. Br. in Kuhn, Fil. Afr. 212. 1868, category taken from annotation of type by A. Br. (Holotype: *Balansa* B!. *Peters*, Mozambique, is excluded as a type; it is *S. Dregei*).

Selaginella rupestris ssp. *Balansae* (A. Br.) [incorrectly attributed to Hieron. by] Jahand. & Maire, Cat. Pl. Maroc. 1:11. 1931.

Rhizomes short, creeping; aerial branches with buds present at their base which are sometimes elongated to form stolons, erect or ascendent, rarely some decumbent. Leaves with the base decurrent and blending into the stem in color on the basal portion of the stem, rather abruptly adnate on the apical portion; margins ciliate, the cilia dentiform, about ⅛ or less as long as the width of the blade; apex nearly flat to slightly rounded; setae tawny to whitish, subopaque to translucent. Megaspores rugose on the commissural face, less prominently rugose-reticulate on the outer face, pale yellow to pale orange.

The unusual distribution of the series *Arenicolae* results from the inclusion of this North African species. However, the range of the series is not unlike that of the genus *Platanus*. Superficially *S. Balansae* bears a close resemblance to *S. rupincola* but in technical characters it is probably closest to *S. arenicola*. The localities taken from the literature (Map 13) are from Jahandiez and Maire, Cat. Pl. Maroc. 1:11. 1931.

This species grows in exposed rocky places at 200–1200 m.

Morocco and Spanish Morocco.

Representative specimens:

Morocco: Gorges de l'Oued-Ghaghaia, au sud de Maroc, June 3, 1867, *Balansa* (B, K, P, NY, US); *De Retz 31681* (MO); 1908, *Gandoger* (MO); 1935, *Gattefossé* (US); 1871, *Hooker* (NY); *R. Maire 1533* (P).
Spanish Morocco: *Quer 1* (BM).

5. Selaginella Weatherbiana Tryon, in Amer. Fern Jour. 40:69. 1950. (Holotype: *Standley 4558* MO!. Paratypes: *Drouet & Richards 3337* MO!; *Ewan 14370* MO!; *Macbride 2651* MO!; *Standley 4158* US!, *4626* MO! NY! US!; *Underwood* NY!; *Underwood & Selby 2* NY!). Figs. 7, 8. Map 14.

Rhizomes widely creeping; aerial branches with buds rarely present at their base, erect or ascendent, rarely some decumbent. Leaves with the base decurrent and blending into the stem in color on the basal portion of the stem, less decurrent, sometimes rather abruptly adnate on the apical portion; margins ciliate, the cilia dentiform, about 1/6 as long as the width of the blade; apex carinate; setae lutescent- to greenish-white, translucent. Megaspores rather coarsely rugose-reticulate, rarely nearly smooth on the outer face, pale yellow to pale orange.

The rhizomes, the strongly carinate leaf-apex and the greenish-white or lutescent setae are characteristic of this species. It often grows in close association with S. *Underwoodii* and, largely on the basis of fragmentary material, was long confused with it.

Selaginella Weatherbiana grows on exposed or shaded rocky hillsides and cliffs, in crevices and on ledges of igneous rock at 2000–3200 m.

Colorado and New Mexico.

Representative specimens:

United States. colorado: *Ewan 14370* (MO); *Macbride 2651* (MO); *R. M. & A. F. Tryon 5077* (ARIZ, B, BM, CU, DS, F, FI, GH, K, MICH, MIN, MO, NY, P, PH; POM, RM, UC, US, WS); Sept. 1901, *Underwood* (NY); *Underwood & Selby 2* (NY). new mexico: *Arsène 17817* (US), *17980* (US); *Drouet & Richards 3337* (F, MO); mouth of Indian Creek, San Miguel Co., 8000 ft., July 25, 1908, *Standley 4558* (F, MO, NY, US); *Standley 4158* (US), *4626* (MO, NY, US), *14692* (F, US).

6. Selaginella viridissima Weath. in Jour. Arn. Arb. 24:326. 1943. (Holotype: *Stewart 2204* GH!. Paratype: *Johnston 8683* GH!). Fig. 9. Map 15.

Selaginella Coryi Weath. in Amer. Fern Jour. 36:51. 1946. (Holotype: *Cory 44831* GH! fragment US!).

Rhizomes widely creeping; aerial branches with buds rarely present at their base, erect or ascendent, occasionally some decumbent or prostrate. Leaves with the base decurrent and blending into the stem in color on the basal portion of the stem, less decurrent, essentially distinct in color on the apical portion; margins ciliate, cilia dentiform, 1/8 to 1/6 as long as the width of the blade; apex broadly rounded to carinate, muticous. Megaspores rugose, pale orange.

The muticous leaves afford the best character to distinguish S. *viridissima* from the other species of the series. An additional character is the very slender stems.

From additional material it is evident that S. *Coryi* can not be maintained on the basis of habit; both the Mexican and Texan material have erect or ascendent branches and some prostrate ones in the same mats.

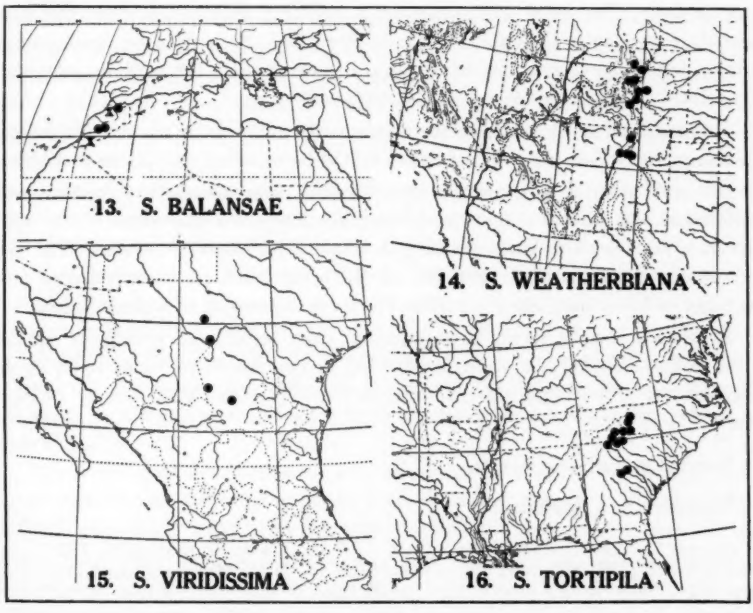
S. *viridissima* forms large, loose mats, rarely partly pendent, on shaded or locally sheltered cliffs and ledges of igneous rock.

Southwestern Texas and Coahuila.

Specimens examined:

UNITED STATES. TEXAS: *Correll 13627* (MO); Chisos Mountains, Brewster Co., July 10, 1944, *Cory 44831* (GH, US); May 24, 1928, *Murray* (F); *R. M. & A. F. Tryon 5015* (ARIZ, B, BM, DS, F, FI, GH, K, MICH, MO, NY, P, PH, RM, UC, US); *Warnock 21694* (US).

MEXICO. COAHUILA: *Johnston 8683* (GH); *Kenoyer & Crum 2620* (GH); Cañon de Calabasa, north wall of Sierra Maja, Oct. 27, 1941, *Stewart 2204* (GH).



7. SELAGINELLA TORTIPILA A. Br. in Ann. Sci. Nat. V. 3:271. 1865. (Lectotype: *Rugel* B!. Paratype: *Curtis* B!). Fig. 10. Map 16.

Selaginella rupestris (L.) Spring var. *tortipila* (A. Br.) Underw. Our Nat. Ferns, ed. 3, 140. 1888.

Selaginella Sherwoodii Underw. in Torreya 2:172. 1902. (Lectotype: *Sherwood* in 1902 NY!. Paratypes: *Donnell-Smith* in 1882 NY!; comm. *Sherwood* in April, 1902 NY!; *Sherwood* in 1901 NY!. *Donnell-Smith* in 1881 NY! is excluded as a type, it corresponds to the type of S. *tortipila*).

Selaginella rupestris var. *Sherwoodii* (Underw.) Clute, Fern Allies, 142. 1905.

Rhizomes widely creeping; aerial branches with buds sometimes present at their base, erect or ascendent, occasionally some decumbent. Leaves with the base decurrent and blending into the stem in color; dorsal groove absent or developed only in the mid-portion of the blade; margins eciliate to ciliate, the cilia dentiform to piliform, up to 1/6 as long as the width of the blade; apex carinate to strongly carinate; setae with a filiform, tortuous to irregularly flexuous, often deciduous, tip, rarely lacking a modified tip, lutescent- to greenish-white, translucent to subopaque. Megaspores rugose to tuberculate, rarely smooth on the outer face, pale yellow to pale orange.

The two distinctive characters of S. *tortipila*, the poorly developed dorsal groove and the tortuous, filiform seta tip, are somewhat variable. Rarely on some leaves of a stem the dorsal groove may be quite well developed or the setae may be nearly straight and stouter than usual. The strobili are usually very short, about 5 mm. long or less. The basal sporophylls of a strobilus usually die after the leaves beneath; occasionally they die before. S. *arenicola* is the only other species in the series in which the sporophylls die before the leaves beneath the strobilus, this being a character of ssp. *arenicola* and ssp. *acanthonota*.

I am indebted to Dr. A. J. Sharp for adequate collections of this species showing the rhizomes, a character only suggested by the many other collections available.

Wherry[21] pointed out, on the basis of field observation, that specimens described and identified as S. *Sherwoodii* were portions from the center or the upper part of a mat, or from mats growing in unusually exposed situations. The type and similar specimens of S. *tortipila*, on the other hand, represent material from the outer or lower portions of a mat or from a mat growing in a shaded place.

S. *tortipila* usually forms large, compact mats on exposed granite or granite-gneiss cliffs or rocks; less often in thin soil in depressions of rocks or in shaded localities. It grows from 900–1500 m. in North Carolina to as low as 90 m. in Georgia.

North Carolina to Georgia.

Representative specimens:

UNITED STATES. NORTH CAROLINA: *D. S. & H. B. Correll 7897* (GH, US); 1882, *Donnell-Smith* (GH, MO, NY, US); 1898, *Huger* (B, NY); *Hunnewell 9478* (GH, US), *9479* (GH, US); *Oosting 3640* (MO); Broad River,[22] July, 1841, *Rugel* (B, NY, US); Highlands, Macon Co., 1902, *Sherwood* (NY); April, 1902, comm. *Sherwood* (NY). SOUTH CAROLINA: *Curtis* (B); 1881, *Donnell-Smith* (F, GH, MO, NY, US). GEORGIA: *Duncan et al. 9084* (GH, MO); *Hermann 10108* (F, GH, MO, NY, US); *Pyron & McVaugh 2056* (US).

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[21] Jour. South. Appalach. Bot. Club 1:65–69. 1936.

[22] Wherry, E. T. in Jour. South. Appalach. Bot. Club 1:68. 1936, says that this species grows along the Broad River only at Chimney Rock, Rutherford Co. Presumably Rugel made his collection there.

SERIES **Sartorii** Tryon, ser. nov.

Rhizomata et stolones nulla, gemmae breves simplices ad bases caulium rare praesentes vel absentes. Caules prostrati vel ramis rare ascendentibus vel erectis. Apices ramorum recti vel involuti statu inerte. Caules frondosi valde dorsiventrales vel radialiter symmetricales. Folia base abrupte adnata cum caule distincta colore vel folia caulium primariorum rare decurrentia. Typus: *Selaginella Sartorii* Hieron.

Plants terrestrial or, in S. *extensa*, sometimes epiphytic; rhizomes and stolons absent; short, simple, basal buds present only in S. *Dregei*, and then rarely. Stems prostrate with rhizophores produced generally throughout or, in S. *Dregei*, often irregularly ascendent, or in S. *proxima* and S. *Wightii* the primary branches tending to be erect or ascendent and dendroid with rhizophores few or absent among the branches; stems moderately long to long, or in S. *macrathera* and S. *carinata*, short, or in S. *extensa*, very long; usually forming loose, open, less often compact mats. Branches long to short, remote to approximate, usually intricate; branch tips straight or, in the dorsiventral species, involute in the dormant state; the older primary branches of the main stem (excluding dichotomous branches) once to three, rarely four times pinnate. Leafy stems radially symmetrical, the leaves equal in length, shape, position and texture on all sides of the same portion of the stem, to strongly dorsiventral with the under leaves appressed, the upper erect, the under longer than the upper and different in shape and texture; zone of green leaves equal on all sides of the stem to much longer on the upper side in the dorsiventral species. Leaves with the base abruptly adnate, distinct from the stem in color, or those on the main stems slightly decurrent; apical portion plane or incurved or, in S. *extensa*, revolute; setae straight or nearly so, or in S. *Dregei* and S. *proxima*, strongly curved, entire, or in the upper leaves of S. *echinata*, stellate or substellate. Strobilus with the sporophylls in four ranks, radially symmetrical or dorsiventral, those on the under side longer and broader than those on the upper side or, in S. *Dregei*, with the sporophylls in two ranks on the under side of the branch tip.

This is the most heterogeneous series consisting of three species groups that in a more elaborate classification might be given formal recognition. The least specialized and presumably most primitive group, S. *Sellowii* to S. *extensa*, has the leafy stems and strobili radially symmetrical. The first three species, S. *Sellowii*, S. *Sartorii* and S. *Wightii*, are quite generalized in their characters, the others are specialized in one or more ways. The next group, S. *Wrightii* to S. *indica*, has dorsiventral leafy stems and radially symmetrical strobili. All of the species are specialized in some character. The last and most marked group, S. *njamnjamensis* to S. *Dregei*, has the leafy stems radially symmetrical or dorsiventral and the strobili dorsiventral. These are probably the most highly evolved species in the section and among them S. *echinata* of Madagascar stands as the most specialized. The character of the dorsiventral strobilus has been observed very rarely in S. *mutica* of this series and in S. *Parishii* in *Eremophilae*.

Nearly all of the species of the series are quite distinctive and many of them are exceptionally so. The few close relations that afford a critical separation are S. *Sellowii* and S. *Sartorii*, S. *njamnjamensis* and S. *caffrorum* and perhaps S. *cinerascens* and S. *Arsenei*.

The following specimen may represent a new species of the *Sartorii* but the material is sterile and thus inadequate: M'pala ad litt. occid. lacus Tanganyika, 1898, *Rev. Guillemé & (P)*. It may be a variant of S. *Wightii* var. *Phillipsiana* to which it is evidently related. Its most distinctive character is the margin of the leaf that is smooth or bears a few minute, dentiform cilia. An annotation label by Hieronymus notes it as a new species bearing the name of the collector.

KEY TO SPECIES

a. Sporophylls in four ranks, the strobilus radially symmetrical. New World, Asia, 1 species in eastern Africa. b.
  b. Leafy stems radially symmetrical or nearly so, *or* dorsiventral only in the position of the leaves, the upper and under leaves equal in length and shape or very nearly so on the same portion of the stem. c.
    c. Apical portion of leaves essentially plane or incurved. d.
      d. Apex of the blade plane or gently beveled in profile, flat to rounded. e.
        e. Cilia, especially of the leaves of the main stems, piliform, or dentiform only toward the apex of the blade; *or* if all cilia dentiform then the setae milk-white, opaque; *or* leaves eciliate. f.
          f. Leaves definitely setate. g.
            g. Older primary branches once to rarely twice pinnate; apex of the leaves usually convexly acute to acuminate. New World. h.
              h. Leaf-bases glabrous; setae usually milk-white, opaque, if whitish to greenish-lutescent and subtranslucent (Brazil) then slightly attenuate. Mexico, Cuba, Venezuela to Argentina and Brazil ..... 8. S. *Sellowii*, p. 34
              h. Leaf-bases predominantly pubescent, or if rarely mostly glabrous then the setae strongly attenuate; setae whitish to greenish to lutescent, translucent to subopaque. Mexico, Colombia and Venezuela ..... 9. S. *Sartorii*, p. 36
            g. Older primary branches twice to three times pinnate; apex of the blade long-acuminate. India and Africa ..... 10. S. *Wightii*, p. 39
          f. Leaves, especially of the growing tips of the secondary branches, muticous or with a slightly modified apex. Southern California and Baja California ..... 11. S. *cinerascens*, p. 40
        e. Cilia of the leaves dentiform; setae whitish or greenish- to lutescent-whitish, translucent to subopaque. Mexico. i.

i. Setae about 1/5 or less as long as the blade.....12. S. *Arsenei*, p. 41
i. Setae 3/5 to usually 2/3 as long as the blade..13. S. *macrathera*, p. 41
d. Apex of the blade predominantly truncate to abruptly beveled in profile, especially those of the growing-tips, broadly rounded to carinate. j.
j. Apex of the sporophylls carinate; leafy stem somewhat dorsiventral in the position of the leaves. Japan..14. S. *shakotanensis*, p. 43
j. Apex of the sporophylls rounded to broadly rounded, *or* if carinate then the leafy stem quite or essentially radially symmetrical. k.
k. Leaves ligulate to ligulate-long-triangular, definitely setate. Montana to British Columbia and California..15. S. *Wallacei*, p. 43
k. Leaves oblong- to ovate-lanceolate, muticous or nearly so in Colorado and Utah, setate southward.....16. S. *mutica*, p. 44
c. Apical portion of many leaves revolute. Mexico.....17. S. *extensa*, p. 47
b. Leafy stems strongly dorsiventral, the under leaves with the blade definitely longer than the upper on the same portion of the stem, or different in shape, or in both length and shape. l.
l. Sporophylls long-ciliate toward the base; under leaves linear; setae arising very evenly in form and usually in color from the blade-apex or the leaves muticous.....18. S. *Wrightii*, p. 48
l. Sporophylls eciliate to short-ciliate toward the base. m.
m. Setae arising rather abruptly in form and color from the blade-apex. New World. n.
n. Apex of the blade flat to rounded; some red leaves usually present, especially among the under ones. o.
o. Apex of the blade of the upper leaves long-acuminate; under leaves papyraceous. Guatemala and adjacent Mexico.....19. S. *Steyermarkii*, p. 49
o. Apex of the blade of the upper leaves acute to convexly acute; under leaves herbaceous. California.....20. S. *Hansenii*, p. 49
n. Apex of the blade carinate; no red leaves present. Ecuador.....21. S. *carinata*, p. 50
m. Setae arising evenly in form and usually also in color from the blade-apex; under leaves papyraceous. India.....22. S. *indica*, p. 52
a. Sporophylls in two ranks, or in four ranks and the strobilus dorsiventral, the sporophylls of the under side longer and broader than those of the upper side. Africa and Madagascar. p.
p. Sporophylls in four ranks; longest cilia of the leaves up to 1/2 as long as the width of the blade. q.
q. Setae whitish to tawny or lutescent, entire. Africa. r.

r. Under leaves herbaceous, the base abruptly adnate, distinct from the stem in color; setae poorly differentiated from the blade-apex in form and color ..... 23. S. *njamnjamensis*, p. 52

r. Under leaves papyraceous to papyraceous-herbaceous, the base often decurrent, blending into the stem in color on the main stem; setae predominantly whitish, rather abruptly distinct from the blade-apex in form and color ..... 24. S. *caffrorum*, p. 53

q. Setae milk-white, opaque, entire, *or* those of the upper leaves, especially at the branch-tip, whitish, substellate, soon deciduous. Madagascar. s.

s. Setae of upper leaves substellate, soon deciduous ..... 25. S. *echinata*, p. 54

s. Setae entire, persistent. t.

t. Setae straight, ¼ to ⅓ as long as the blade ..... 26. S. *nivea*, p. 55

t. Setae strongly curved, ⅓ to ½ as long as the blade ..... 27. S. *proxima*, p. 56

p. Sporophylls in two ranks; longest cilia of the leaves ½ as long to as long as the width of the blade; setae usually strongly curved. Africa ..... 28. S. *Dregei*, p. 57

8. Selaginella Sellowii Hieron. in Hedwigia 39:306. 1900, maintained over S. *Arechavaletae* and S. *montevideensis* by Alston, in Physis 15:252. 1939. (Lectotype: *Sellow* in 1821 B! fragment NY!; *Ule 232* US is nearly identical. Paratypes: *De Moura 908* B; Rio de Janeiro, *Gaudichaud* B; *Riedel 7* B; *Schwache 949* B; *Lhotzky 7* B). Fig. 11. Map 17.

Selaginella rupestris (L.) Spring f. *amazonica* Milde, Fil. Europ. Atlant. 263. 1867. Holotype: *Humboldt & Bonpland* B!; Peru, Galathea Exped. US 619317 is an excellent match).

Selaginella rupestris f. *brasiliensis* Milde, Fil. Europ. Atlant. 263. 1867. (Lectotype: *Sellow* in 1821 B! fragment NY!. Paratype: *Sellow* B! fragment NY!. *Moritz 370* B! is excluded as a type, it is S. *Sartorii*).

Selaginella rupestris var. *brasiliensis* (Milde) Hieron. in Engl. Bot. Jahrb. 22:417. 1896, not S. *brasiliensis* (Raddi) A. Br. 1865.

Selaginella montevideensis Hieron. in Hedwigia 39:309. 1900. (Lectotype: *Sellow 670* B! fragment NY!; *Gibert 1323* has been annotated at NY as a close match. Paratype: *Gaudichaud* B!).

Selaginella amazonica (Milde) Hieron. in Hedwigia 39:310. 1900, not S. *amazonica* Spring, 1840.

Selaginella Arechavaletae Hieron. in Hedwigia 39:311. 1900. (Holotype: *Arechavaleta 472* B! fragment NY!; *Herter*, Pl. Urug. 2077 is a close match).

Selaginella Mildei Hieron. in Engl. & Prantl, Nat. Pflanz. 1^4:671. 1901, based on S. *amazonica* (Milde) Hieron.

Selaginella paucicilíata Hieron. in Hedwigia 58:284. 1916. (Holotype: *Wright 1820* B!, *Wright '20'* cited by Hieron. is actually *1820* as indicated by an extra label on the sheet at GH).

Stems with the older primary branches once to rarely twice pinnate; leafy stems radially symmetrical to rarely somewhat dorsiventral in position, length and shape of the upper and under leaves. Leaves herbaceous, none red, subulate-long-

triangular to broadly ligulate to lanceolate; base abruptly adnate, distinct from the stem in color or sometimes rather decurrent on the leader stem, glabrous; margins eciliate or usually ciliate, the cilia usually piliform, dentiform only at the apex of the blade, occasionally all dentiform, the longest cilia about 1/5 to rarely 1/2 as long as the width of the blade; apex usually acute to convexly acute, sometimes acuminate, slightly to definitely rounded, plane to rather abruptly beveled in profile; setae arising evenly or abruptly in form and color, 1/4 to nearly 1/2 as long as the blade, slightly attenuate, milk-white and opaque to greenish- or whitish-lutescent and subopaque to translucent. Sporophylls with the margins eciliate to moderately long-ciliate toward the base; apex rounded. Megaspores rugose to rugose-reticulate on the commissural face, rugose-reticulate to smooth on the outer face, yellow to orange-yellow.

This species and the next, S. *Sartorii,* are not well separated by distinctive morphological characters although in the regions where they both occur, Mexico, Colombia and Venezuela, the distinctions are adequate. Each is sufficiently variable, however, so that they overlap in the total range of variation of the characters. I would regard the two as something more than subspecies and yet less than species as judged by the attributes of the other species of the series. However, since they are clearly separable it seems best to give them specific status. S. *Sellowii* is characterized by glabrous leaf-bases and milk-white, opaque setae, while S. *Sartorii* has pubescent leaf-bases and whitish to greenish-lutescent and translucent to subopaque setae. Some Brazilian material of S. *Sellowii* is exceptional in having setae characters like S. *Sartorii* and rarely some Mexican material of S. *Sartorii* will have glabrous leaf-bases.

S. *Sellowii* is composed of three major variants all of which intergrade rather freely. The value of the characters and particularly their degree of correlation is less than in S. *mutica,* for example, where varieties are maintained. For these reasons, the variants are not accorded a status.

The most common variant has the leafy stem radially symmetrical, the leaves narrowly long-triangular to long-triangular with the apex plane in profile, with few or no cilia and with the setae milk-white and opaque. This ranges from Bahia, Brazil, to Argentina and Bolivia with slight variants extending northward to Mexico and Cuba. The material from Ecuador and northern South America has the leaves piliform-ciliate; that from Mexico and Cuba has the leafy stem more slender. The type specimens of S. *paucicilíata,* S. *Sellowii,* S. *Arechavaletae* and S. *montevideensis* are this variant although those of the last three are somewhat intermediate with the next.

The second variant is usually slightly dorsiventral; the leaves are broadly ligulate to ligulate-lanceolate with the apex slightly beveled in profile, with numerous cilia and with the setae whitish and often subopaque. It grows from Rio Grande do Sul, Brazil, to Argentina and Peru. The type specimen of S. *Mildei* belongs here.

The third variant is similar to the second but the leafy stem is very slender; the leaves are not as broad and the setae are greenish- to whitish-lutescent and translucent to subopaque. It is known from the state of Rio de Janeiro, Brazil, and from Rio La Plata (*Selding*, GH).

It is evident that Hieronymus essentially based S. *Sellowii* on S. *rupestris* f. *brasiliensis*, the epithet *brasiliensis* having been previously used at the specific level. However, he did not do it precisely so I am choosing the same type specimen for both names. This species and S. *Sartorii* are both quite generalized in their characters and probably represent the basic New World type of this series. The localities taken from the literature (Map 17) are from Alston, in Physis 15:253. 1939.

On exposed or wooded rocky bluffs and cliffs or among stones, less often in sandy or clay soil, usually at about 1000–2000 m. but ranging from sea level to 2700 m.

Central Mexico; Cuba; Venezuela to Colombia, Argentina and eastern Brazil.

Representative specimens:

CUBA: Mayari, Holquin, Aug. 17, 1859, 1860, *C. Wright 1820* (B, GH, K, MO, NY, YU).

MEXICO. DISTRITO FEDERAL: *Rose & Painter 6835* (US). PUEBLA: *Arsène 891* (US), *10639* (US). VERACRUZ: *Liebmann 2062* (US).

VENEZUELA: *Tamayo 298* (US).

COLOMBIA: *Lehmann KK97* (US), *BT776* (US).

ECUADOR: *Jameson 426* (US); *Sodiro 47/1* (B).

PERU: *Bües 608* (US); *Herrera 3009a* (US); ad ripam fluminis Marañon, *Humboldt & Bonpland* (B).

BOLIVIA: *Balls 6229* (US); *Eyerdam 25041* (F, GH); *Steinbach 8254* (F, GH, MO), *8574* (F, GH, MO); *R. S. Williams 1400* (US).

ARGENTINA: *Bartlett 20456* (US); *Burkart 809* (GH), *3308* (GH), *7128* (GH), *10113* (MO); *Burkart & Troncoso 11174* (MO); *Lossen 246* (F, MO); *T. Meyer 2227* (GH), *3687* (NY, US); *Schulz 753* (GH); *L. B. Smith 4679* (US); *Venturi 1144* (GH, US), *1866* (GH, US).

PARAGUAY: *Fiebrig 4907* (GH, US); *Hassler 12535½* (US); *Jorgensen 4073* (F, NY); *Lindman A2319* (US).

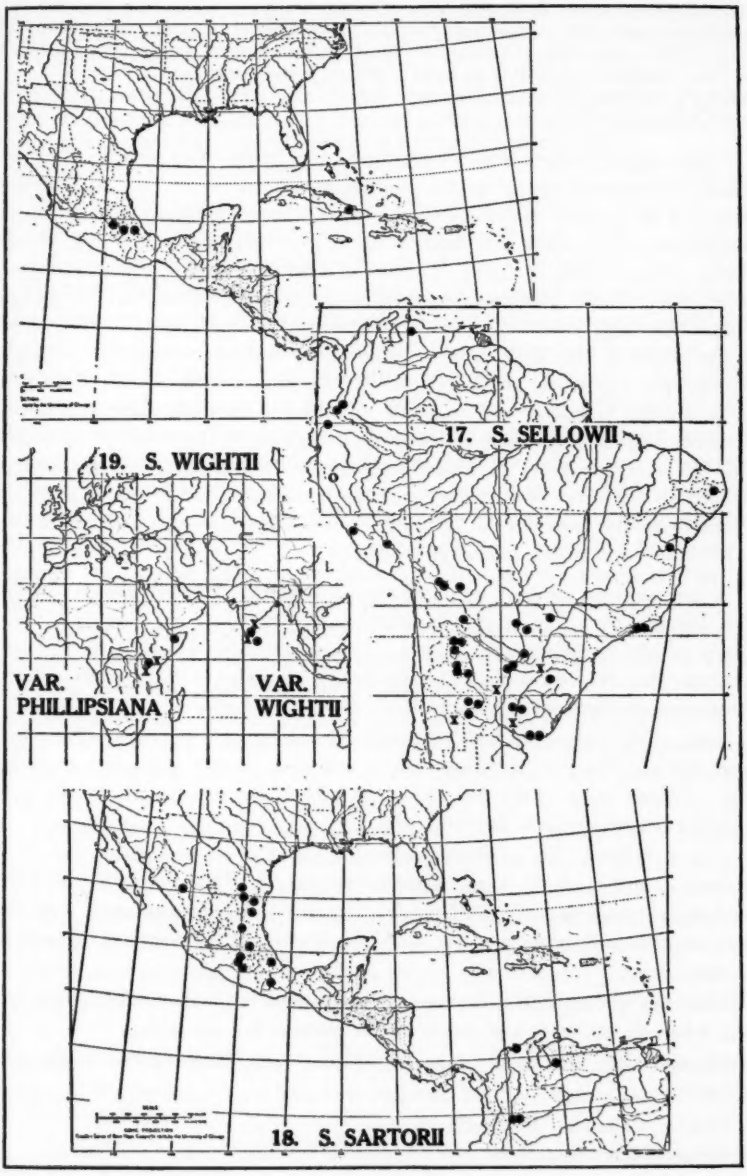
URUGUAY: Montevideo, June, 1876, *Arechavaleta 472* (B, K, NY); Montevideo, *Gaudichaud* (B); *Gibert 1323* (NY, US); *Herter 76113* (GH, MO), *78856* (F), *94884* (MO), *99600* (MO); Montevideo, *Sellow 670* (B, K, NY).

BRAZIL: *Archer & Gehrt 118* (US); *Dusén 14* (US); *Glaziou 3306* (US); *Jürgens 29* (NY), *308* (US), *309* (US); *Lindman A213* (US); *Lützelberg 18870* (NY); *Riedel 7* (GH); *Rose & Russell 19937* (NY, US); *Sellow* (B, NY), Praia de San Diego, 1821, *Sellow* (B, NY); *Ule 232* (US); *Wilkes*, U. S. So. Pacific Expl. Exped. (GH, NY, US, YU); 1934, *S. Wright* (GH).

9. SELAGINELLA SARTORII Hieron. in Hedwigia 39:304. 1900. (Lectotype by Weath. in Jour. Arn. Arb. 25:418. 1944: *Sartorius* B!. Paratypes: *Liebmann* in Aug. 1841 B; *Schiede* in May, 1829 B). Fig. 12. Map 18.

Selaginella Sartorii var. *oregonensis* Hieron. in Hedwigia 39:305. 1900. (Holotype: *"Lyall"* B! fragment NY!, collector and locality unknown).

Selaginella Sartorii var. *venezuelensis* Hieron. in Hedwigia 39:305. 1900. (Holotype: *Moritz 370* B!).


19. S. WIGHTII
17. S. SELLOWII
VAR. PHILLIPSIANA
VAR. WIGHTII
18. S. SARTORII

Selaginella rupestris (L.) Spring var. *Sartorii* (Hieron.) Frye, Ferns Northwest, 31. 1934.
Selaginella porrecta Weath. in Jour. Arn. Arb. 25:416. 1944. (Holotype: *Pennell 17198* US! fragment GH!. Paratypes: *Bartlett 10355* US!, *11039* US!; *Orcutt 1098* US!, *1142* US!, *1151a* US, *5125* US!; *Ortega 5319* US!; *Pennell 17753* US!; *Tharp 1792* US!. *Schaffner 933* YU! is excluded as a type; it is *S. peruviana*).
Selaginella Hintonii Weath. in Jour. Arn. Arb. 25:418. 1944. (Holotype: *Hinton 8423* GH! fragment US!).

Stems with the older primary branches once to rarely twice pinnate; leafy stems radially symmetrical except in the position of the leaves, or very slightly dorsiventral in the position and shape of the leaves. Leaves herbaceous to herbaceous-papyraceous, often some red, ligulate to ligulate-long-triangular; base abruptly adnate, distinct from the stem in color or sometimes slightly decurrent on the leader stems, usually pubescent, rarely glabrous; margins ciliate, the cilia piliform, or dentiform only toward the apex of the blade, the longest cilia ¼ to ½ as long as the width of the blade; apex acuminate to convexly acute, flat to slightly rounded, plane to gently beveled in profile; setae arising rather evenly in form but less so in color, ¼ (rarely less) to nearly ½ as long as the blade, slightly to strongly attenuate, whitish to greenish to lutescent, subopaque to translucent. Sporophylls with the margins short- to rather long-ciliate toward the base; apex slightly rounded to carinate. Megaspores prominently and irregularly rugose to rugose-reticulate on the commissural face, more prominently marked to nearly smooth on the outer face, yellow to orange-yellow.

S. Sartorii is not strongly separated from *S. Sellowii*. The Venezuelan specimens of *S. Sartorii*, for example, are identified by the pubescent leaf-bases, a character that is usually variable within a species. They also differ from the *S. Sellowii* of that area, however, in the color and opaqueness of the setae. The relations of the two species are discussed in greater detail under *S. Sellowii*.

Some of the Colombian and Venezuelan specimens such as *Lindig 1523*, *Amórtegui A61* and *Tamayo 1753* have some of the leaves with a rather decurrent leaf-base. *Hinton 3453* (BM) has the leaves almost entirely dentiform-ciliate but otherwise it agrees with *S. Sartorii*.

Like *S. Sellowii*, this species is a complex but it is not as variable nor are the extremes as well marked. I am unable to maintain *S. Hintonii* and *S. porrecta* on the basis of characters of specific value in other species in the series. Without more adequate collections it is not clear whether or not they represent geographic variants.

The type specimen of *S. Sartorii* var. *oregonensis* at Berlin incorrectly bears a Lyall label; the collector and source of the material are not known.

Exposed cliffs and rocky slopes of igneous rock, sandstone or limestone at 870–2000 m.

Mexico, Colombia, Venezuela.

Representative specimens:

MEXICO. TAMAULIPAS: *Bartlett 10355* (US), *11039* (US); *Meyer & Rogers 3112* (MO); *Stanford et al. 2187* (MO). NUEVO LEON: *Orcutt 1098* (US), *1142* (US), *1151a* (US); "Alamar", Pablillo, southeast of Galeana, 1650–1700 m., July 2–3, 1934, *Pennell 17198* (GH, US); *Tharp 1792* (US). SAN LUIS POTOSI: *Orcutt 5125* (US); *Pennell 17753* (US). DURANGO: *Ortega 5319* (US). MEXICO: Ypericones, Temascaltepec, Sept. 7, 1935, *Hinton 8423* (GH, US). VERACRUZ: Mirador, *Sartorius* (B); 1841, *Liebmann* (GH); *Purpus 8463* (GH, MO, US). OAXACA: *Andrieux 2* (GH); *Kenoyer 1566* (GH).
COLOMBIA: *Amórtegui A61* (US); *Lindig 1523* (GH); *Purdie* (YU).
VENEZUELA: Paramo de Mucuchies, *Moritz 370* (B, K, YU); *Tamayo 1753* (US), *1773* (US).

10. SELAGINELLA WIGHTII Hieron. in Hedwigia 39:319. 1900. (Lectotype: *Wight 15* B!. Paratypes: *Walker* B; *Wight 283* B, *3194* B!). Map 19.

Stems with the primary branches tending to be ascendent and dendroid, the older primary branches twice to three times pinnate; leafy stems radially symmetrical or nearly so. Leaves herbaceous to herbaceous-papyraceous, none red, long-triangular to ligulate-long-triangular; base abruptly adnate, distinct from the stem in color, glabrous; margins ciliate, the cilia piliform, or dentiform toward the apex, the longest cilia ¼ to ½ as long as the width of the blade; apex long-acuminate, flat to slightly rounded, plane to slightly beveled in profile; setae arising evenly in form and often in color, ⅕ to nearly ½ as long as the blade, slightly to strongly attenuate, whitish-lutescent, translucent to subopaque. Sporophylls with the margins eciliate to short-ciliate toward the base; apex broadly rounded to carinate. Megaspores rather finely rugose-reticulate on the commissural face, more coarsely and less prominently marked on the outer face, pale orange-yellow.

S. Wightii is the most generalized Old World species in the series and probably represents the basic type for that region as *S. Sellowii* and *S. Sartorii* do for Tropical America. It is most closely related to *S. njamnjamensis*.

The African and Indian plants are very closely related. On the basis of relatively few collections it seems to be distinct but not in characters of specific value. Ample material may indicate a need to change the varietal status given the African plant here.

Southern India and Ceylon, eastern Africa.

KEY TO VARIETIES

a. Setae predominantly strongly attenuate; sporophylls eciliate to only slightly ciliate toward the base ..... 10a. var. *Wightii*, p. 39
a. Setae stout to predominantly slightly attenuate; sporophylls predominantly short-ciliate toward the base ..... 10b. var. *Phillipsiana*, p. 40

10a. SELAGINELLA WIGHTII var. **Wightii**. Fig. 13. Map 19.

Selaginella Wightii var. *vetusta* Hieron. in Hedwigia 39:320. 1900, ex char. (Holotype: Mauritius, *Sieber ?* B).

The localities taken from the literature (Map 19) are from Alston, in Proc. Nat. Inst. Sci. India 11:215. 1945. Although I have not seen the type of var.

vetusta said, probably in error, to come from Mauritius, the description does not adequately separate it from var. *Wightii*. In addition, I have seen *Gamble 17258* (P) identified by Hieronymus as var. *vetusta* and it is typical var. *Wightii*.

Rocky places, 700–1700 m.

Southern India and Ceylon.

Specimens examined:

India: *Gamble 17258* (P); *Wallich 2188/3* (BM, US); Peninsula Ind. orientalis, *Wight 15* (B, BM, K, P), *Wight 283* (B, K), *3194* (B, GH, K).
Ceylon: *W. Ferguson 233* (US); *Thwaites 1414* (P); *Walker* (GH).

10b. Selaginella Wightii var. Phillipsiana Hieron. in Hedwigia 39:320. 1900. (Holotype: *Phillips* B!).

Selaginella Phillipsiana (Hieron.) Alston, in Jour. Bot. 77:222. 1939.

The localities taken from the literature (Map 19) are from Alston, in Jour. Bot. 77:222. 1939.

On stones and rocks, 1200–1500 m.

British Somaliland to Tanganyika.

Representative specimens:

British Somaliland: *J. B. Gillett 4681* (K), *4681A* (K); *Glover & Gilliland 480* (BM), *771* (BM); *Godman 6* (BM); Darra-as, 5000 ft., June, 1895, *Mrs. Lort Phillips* (B, K, P).
Kenya: *Napier 2054* (K).
Tanganyika: *Uhlig 845* (BM).

11. Selaginella cinerascens A. A. Eaton, in Fern Bull. 7:33. 1899. (Holotype: *Kimball* GH!). Fig. 14. Map 20.

Selaginella bryoides Underw. Our Nat. Ferns, ed. 6, 138. 1900, not (Kaulf.) Hieron., 1901, not *Lycopodium bryoides* Nutt. ex Baker, 1887; considered as based on *Selaginella cinerascens* A. A. Eaton.

Stems with the older primary branches once to usually twice to rarely three times pinnate; leafy stems radially symmetrical or nearly so. Leaves herbaceous to herbaceous-papyraceous, none red, linear, acuminate to broadly lanceolate; base abruptly adnate, distinct from the stem in color or sometimes rather decurrent on the leader stem, usually glabrous, sometimes pubescent; margins rarely eciliate, usually ciliate, the cilia usually piliform, or dentiform only toward the apex, the longest cilia up to ⅓ as long as the width of the blade; apex acute to nearly obtuse, flat to slightly rounded, plane in profile; setae absent, the apex not or slightly modified, or if present, arising rather abruptly in form and color, up to ⅕ as long as the blade, stout, whitish, opaque to translucent. Sporophylls with the margins eciliate to very short-ciliate toward the base; apex broadly rounded to subcarinate. Megaspores slightly rugose on the commissural face, more prominently marked on the outer face, with an equatorial ring, pale yellow.

S. cinerascens is quite closely related to the next species, *S. Arsenei*. The two may be distinguished by the cilia which are predominantly piliform in *S. cinerascens* and dentiform in *S. Arsenei*. There is a close resemblance to *S. nivea* of Madagascar but this does not extend beyond characters of habit and general aspect.

This species affords the best illustration of the difference in length of leaves on the stem and branches, a character presumably due to some type of inhibition of growth. The leaves on the main stem are the longest, those on the primary branches are shorter and those on the secondary branches are the shortest.

S. cinerascens is one of the few species that is not closely associated with rocky habitats. It grows on hillsides and slopes, among or beneath shrubs and small trees, often in clay soil, sometimes in rocky soil, from sea level to about 200 m.

California and Baja California.

Representative specimens:

UNITED STATES. CALIFORNIA: *Abrams 3399* (F, GH, MO, NY, US); April 12, 1918, *Bethel* (GH, MO, US); National City (San Diego), May, 1897, *L. F. Kimball* (GH, NY); *Parish 10765* (NY, US).
MEXICO. BAJA CALIFORNIA: *Ferris 8474* (NY, US); *Wiggins 4213* (GH, NY, US).

12. SELAGINELLA ARSENEI Weath. in Jour. Arn. Arb. 25:417. 1944. (Holotype: *Arsène 10641* US! fragment GH!. Paratypes: *Arsène 9983* US!, *10643* US!). Fig. 15. Map 21.

Stems with the older primary branches once to twice pinnate; leafy stems radially symmetrical. Leaves herbaceous, none red, ligulate to ligulate-long-triangular; base abruptly adnate, distinct from the stem in color, glabrous to pubescent; margins ciliate, the cilia dentiform, the longest cilia about ⅛ as long as the width of the blade; apex acute to acuminate, rounded, plane or nearly so in profile; setae absent, the apex slightly modified, or if present, arising evenly in form and usually in color, about ⅕ as long as the blade, stout, greenish- to lutescent-whitish, subopaque. Sporophylls with the margins very short-ciliate toward the base; apex broadly rounded. Megaspores slightly and finely rugose-reticulate, lemon-yellow.

The differences between *S. Arsenei* and the closely related *S. cinerascens* are discussed under *S. cinerascens*.

S. Arsenei grows in rocky places, at one locality at 2700 m.

Central Mexico.

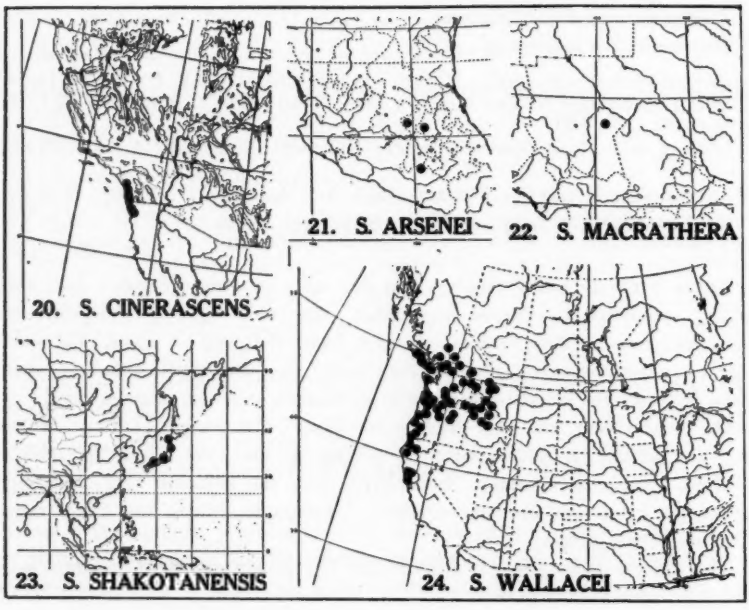
Specimens examined:

MEXICO. SAN LUIS POTOSI: *T. C. & E. M. Frye 2983* (F). QUERÉTARO: Querétaro, 1914, *Arsène 10641* (GH, US), *9983* (US), *10643* (US). HIDALGO: *Hitchcock & Stanford 7248* (US). GUERRERO: *T. C. & E. M. Frye 3149* (US).

13. SELAGINELLA MACRATHERA Weath. in Jour. Arn. Arb. 24:326. 1943. (Holotype: *Johnston 8067* GH!). Fig. 16. Map 22.

Stems short, with the older primary branches once to rarely twice pinnate; leafy stems radially symmetrical. Leaves herbaceous-papyraceous, none red, sub-

ulate; base abruptly adnate, distinct from the stem in color, glabrous to slightly pubescent; margins ciliate, the cilia dentiform, or short-piliform only at the base, the longest cilia ¼ or less as long as the width of the blade; apex acuminate to bluntly acuminate, broadly rounded, plane or nearly so in profile; setae arising abruptly in form and color, ⅗ to usually ⅔ as long as the blade, filiform, white or whitish, subopaque to translucent. Sporophylls with the margins short-ciliate toward the base; apex broadly rounded to carinate. Megaspores slightly to moderately finely rugose on the commissural face, moderately rugose on the outer face, yellow-orange.



Although known from only a single collection there is no doubt that this is a valid species. The dentiform cilia of the leaves and the very long setae distinguish it from all others.

Collected on ledges on north-facing lava cliffs in Chihuahua, Mexico.

Specimens examined:

Mexico. Chihuahua: Sierra del Virulento, 2–3 miles east of Rancho Virulento, ca. 65 miles south of Ojinaga, Aug. 11, 1941, *I. M. Johnston 8067* (GH, MO).

14. SELAGINELLA SHAKOTANENSIS (Franch. ex Takeda) Miyabe & Kudo, in Jour. Fac. Agric. Hokkaido Imp. Univ. 26 (Fl. Hokkaido & Saghal. I):64. 1930. Fig. 17. Map 23.

Selaginella rupestris (L.) Spring var. *shakotanensis* Franch. ex Takeda, in Bot. Mag. Tokyo 23:237. 1909. (Holotype: *Faurie 9895* SAP).

Stems with the older primary branches once to twice pinnate; leafy stems somewhat dorsiventral in the position of the leaves. Leaves fleshy to fleshy herbaceous, none red, ligulate to ligulate-lanceolate; base abruptly adnate, distinct from the stem in color, or sometimes rather decurrent on the leader stems, glabrous; margins ciliate, the cilia piliform, or dentiform only toward the apex, the longest cilia ¼ to ⅓ as long as the width of the blade; apex convexly acute to obtuse, rounded to carinate, abruptly beveled to truncate in profile; setae arising abruptly in form and color, about ⅕ as long as the blade, attenuate, whitish, translucent. Sporophylls with the margins eciliate to long-ciliate toward the base; apex narrowly carinate. Megaspores finely and very slightly rugose-reticulate, orange.

S. *shakotanensis* may be distinguished from S. *sibirica* of *Rupestres*, which overlaps its range, by the shorter setae and the abruptly adnate leaf-bases. The setae are about ⅕ as long as the blade in this species while they are ⅓ as long or longer in S. *sibirica*. The main stem may have some of the leaves with a decurrent base but on the branches the leaf-base is abruptly adnate. S. *shakotanensis* bears a rather close resemblance to S. *mutica* var. *limitanea* from which it may be separated by its slightly dorsiventral leafy stem.

Rocky alpine habitats; one collection was made at 2000 m.

Japan.

Specimens examined:

JAPAN: Aug. 20, 1898, *Faurie* (P), *1577* (P), Shakotan, Yezo Island, Shiribeshi, June 9, 1893, *Faurie 9895* (P, MO), *10543* (P, MO), *13151* (P, MO); U. S. Nat. Herb. sheet 1095388.

15. SELAGINELLA WALLACEI Hieron. in Hedwigia 39:297. 1900, maintained over S. *montanensis* by Broun, Index N. Am. Ferns, 159. 1938. (Holotype: *Wallace* B! fragment NY!). Fig. 18. Map 24.

Selaginella montanensis Hieron. in Hedwigia 39:293. 1900. (Holotype: *A. & A. Krause* B! fragment NY!).

Selaginella rupestris (L.) Spring f. *Wallacei* (Hieron.) Clute, in Fern Bull. 16:52. 1908.

Selaginella rupestris f. *montanensis* (Hieron.) Clute, in Fern Bull. 16:52. 1908, as *montaniensis*.

Selaginella rupestris var. *columbiana* M. E. Jones, in Univ. Mont. Bull. Biol. Ser. 15:8. 1910. (Holotype: *M. E. Jones*, Flathead Lake, near Weiser, Idaho).

Selaginella rupestris var. *Wallacei* (Hieron.) Frye, Ferns Northwest, 33. 1934.

Selaginella Rosendahlii Hieron. ex Frye, Ferns Northwest, 33. 1934, in synon. (Evidently based on *Rosendahl 864*).

Selaginella Wallacei f. *columbiana* (M. E. Jones) Broun, Index N. Am. Ferns, 159. 1938.

Selaginella rupestris var. *montanensis* (Hieron.) [incorrectly attributed to Frye by] Broun, Index N. Am. Ferns, 159. 1938, in synon.

Stems with the older primary branches once to twice, rarely three times pinnate; leafy stems radially symmetrical to rather dorsiventral in position, length and shape of the upper and under leaves. Leaves herbaceous to fleshy, none red, ligulate to ligulate-long-triangular; base abruptly adnate, distinct from the stem in color, sometimes rather decurrent on the leader stems, glabrous or pubescent; margins eciliate or ciliate, the cilia dentiform to usually piliform, the longest cilia 1/5 to 1/4 as long as the width of the blade; apex acute to obtuse, broadly rounded, abruptly beveled to truncate in profile, or predominantly so; setae arising abruptly in form and color, 1/5 to 1/4, rarely 1/3, as long as the blade, rather stout, milk-white and opaque to whitish or greenish-white and translucent. Sporophylls with the margins eciliate to short-ciliate toward the base; apex broadly rounded to subcarinate. Megaspores rugose to rugose-reticulate, usually with an equatorial ring, pale orange.

S. *Wallacei* is one of the most variable species in habit and general aspect. It is also, of the species I know sufficiently, the one with the widest range of habitats and to a considerable extent its variability is correlated with its ecology. Specimens from very damp, shady situations have long stems that form loose mats and the leaves are somewhat distant. Those from dry, exposed rock or gravelly turf have short stems that form a compact mat and the leaves are close.

Of the species that grow within its range it sometimes resembles S. *densa* var. *scopulorum* of *Rupestres*. It may be separated by the remote branches, S. *densa* having approximate ones, and by its abruptly adnate rather than decurrent leaf-bases.

Suskdorf 8563 GH has a strobilus 9 cm. long, the longest I have seen in any species.

Selaginella Wallacei grows on dry, exposed cliffs, talus slopes, rocky bluffs and gravelly soil, or on moist, shaded rocks, bluffs and cliffs, in crevices or covering various types of igneous and sedimentary rocks, from sea level to 2000 m.

Western Montana to southern British Columbia and California.

Representative specimens:

CANADA. BRITISH COLUMBIA: *Hitchcock & Martin 7367* (MO, NY); *Macoun 86372* (GH, NY, US), *86376* (GH, NY, US), *86377* (GH, NY, US); *Rosendahl 864* (BM, MIN, MO, NY, US).

UNITED STATES. MONTANA: Aug. 13, 1908, *M. E. Jones* (BM, MO, US); "Crossing", Northern Pacific Railroad, Oct. 1, 1882, *A. & A. Krause* (B, NY). IDAHO: *Kirkwood & Severy 1718* (GH, US); *H. T. Rogers 763* (GH, MO); *Sandberg et al. 54* (GH, US). WASHINGTON: *Constance & Rollins 998* (F, GH, MO, NY, US); *Otis 1149* (GH, MO, NY, US); *Suskdorf 8563* (GH, MO, US); *Thompson 8747* (F, MO, NY); S. M. & E. B. *Zeller 748* (GH, MO, US). OREGON: *Thompson 4002* (MO, NY, US), *4029* (MO, NY, US), *4102* (MO, US); Oregon, *Capt. Wallace* (B, NY, YU); *Wilkes Exped.* "Wash. & Ore. Terr." (GH, NY, US, YU). CALIFORNIA: *Baker 2746* (GH, NY, US); *Beetle 1566* (GH, MO, NY, US); *Heller 5024* (GH, MO, NY, US).

16. SELAGINELLA MUTICA D. C. Eaton ex Underw. in Bull. Torr. Bot. Club 25:128. 1898. (Lectotype by Weath. in Jour. Arn. Arb. 25:413. 1944: *Meehan* YU! fragment NY!. Paratypes: *M. A. C. Livermore* NY!; *A. G. Compton* NY!; *E. J. Spence* NY!; *Toumey* on Aug. 28, 1894 NY!; *Brandegee*

NY!. *Bigelow* NY! and *Mex. Bound. Survey* NY! are excluded as types; they are intermediates between var. *limitanea* and var. *mutica*).

Stems with the older primary branches once to twice pinnate; leafy stems radially symmetrical. Leaves fleshy to fleshy-herbaceous, none red, ligulate-lanceolate to lanceolate-elliptical to lanceolate-ovate; base abruptly adnate, distinct from the stem in color, or slightly decurrent on the leader stems, glabrous or pubescent; margins ciliate, the cilia entirely piliform, the longest cilia ¼ to ⅓ as long as the width of the blade, to entirely dentiform and shorter; apex obtuse to convexly acute, strongly carinate, subtruncate in profile; setae absent, the apex being scarcely modified, or if present, arising abruptly in form and usually in color, up to ⅕ as long as the blade, stout, whitish to greenish-white, subopaque to translucent. Sporophylls with the margins eciliate to long-ciliate toward the base; apex carinate to narrowly carinate. Megaspores rugose-reticulate to coarsely rugose on the commissural face, less marked to smooth on the outer face, pale orange.

The variation of S. *mutica*, as pointed out by C. A. Weatherby,[23] is rather parallel to that of S. *Underwoodii* which has a very similar range. However, in S. *mutica* the material of Texas, southern New Mexico and southern Arizona is more distinctive and the line of demarcation stronger than in S. *Underwoodii*, so that I am recognizing two varieties. The characters of seta length and ciliation of the sporophylls correlate to a high degree and separate the major components of the species. The southern var. *limitanea* is itself variable but the extremes, one with short, dentiform, ascending cilia on the leaves, and the other with long, piliform, patent cilia, are too often connected by intermediates and the characters vary considerably in some individual mats.

The muticous incurved leaves of var. *mutica* give the stems a reptilian aspect under low magnification.

In Colorado I have seen S. *mutica* growing with S. *Underwoodii* in the same niche. From a number of such cases it appeared quite clear that although the mats of the two species were originally nearly equal in size, S. *mutica* gradually occupied more and more of the niche and finally entirely replaced S. *Underwoodii*.

Rarely a strobilus may be slightly dorsiventral.

Colorado and Utah to Texas and Arizona.

KEY TO VARIETIES

a. Leaves setate; sporophylls with the cilia mostly or entirely ascending, all or some dentiform ..... 16a. var. *limitanea*, p. 46

a. Leaves muticous or nearly so; sporophylls with the cilia entirely or predominantly spreading, piliform ..... 16b. var. *mutica*, p. 46

[23] Jour. Arn. Arb. 25:415. 1944.

16a. Selaginella mutica var. limitanea Weath. in Jour. Arn. Arb. 25:414. 1944. (Holotype: *Goodding* US! fragment GH!. Paratypes: *Ferriss* GH!; *Hinckley 1155* US!; *Ingram 2723* US!; *Moore & Steyermark 3046*, in part, GH!; *E. J. Palmer 31951* US!; *Slater* US!; *Standley* in 1906 US!; *Wooton* in 1899 US!, in 1903 US!, in 1906 US!, in 1909 US!). Map 25.

Selaginella mutica var. *texana* Weath. in Jour. Arn. Arb. 25:414. 1944. (Holotype: *Moore & Steyermark 3196* GH! fragment US!. Paratypes: *Moore & Steyermark 3046*, in part, GH!; *E. J. Palmer 30871* GH!; *Sperry 428* US!. *Tracy & Earle 275* GH! US! and *Mex. Bound. Survey* YU fragment NY! are excluded as types; they are intermediate between var. *limitanea* and var. *mutica*).

Leaves short-setate; cilia mostly or entirely ascending, piliform to dentiform. Sporophylls with the cilia mostly or entirely ascending, all or some dentiform.

Sheltered or moist cliffs and rocky hillsides, on igneous rocks, 1300–2400 m.

Southwestern Texas to southeastern Arizona.

Representative specimens:

United States. texas: *Hinckley 1155* (GH, US); *Ingram 2723* (US); *Moore & Steyermark 3046* (GH, MO, US); ridge south of Emory Peak, Chisos Mountains, Brewster Co., 2300 m., June 22, 1931, *Moore & Steyermark 3196* (GH, MO, US); *E. J. Palmer 30871* (GH, MO, US), *31951* (MO, US); *Sperry 428* (US). new mexico: mountains south of Deming, Oct. 4, 1937, *Goodding* (GH, US); Dec., 1924, *Slater* (US); Sept. 10, 1899, *Wooton* (US), April 18, 1903 (NY, US), June, 1906 (US), Jan. 9, 1909 (US). arizona: March, 1904, *Ferriss* (GH).

16b. Selaginella mutica var. **mutica**. Fig. 19. Map 26.

Selaginella Watsonii mutica (D. C. Eaton ex Underw.) Clute, Fern Allies, 144, 264. 1905.

Leaves muticous or nearly so; cilia entirely or predominantly spreading, piliform. Sporophylls with the cilia entirely or predominantly spreading, piliform.

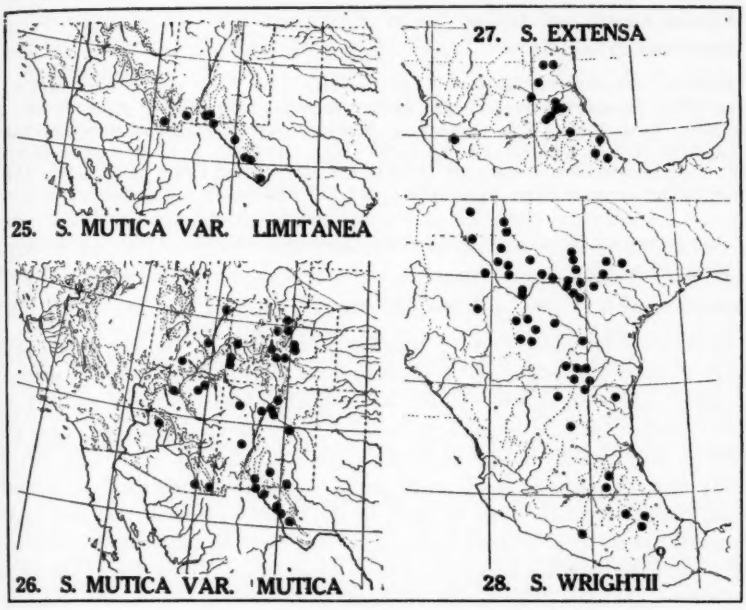
The following specimens are intermediate between var. *mutica* and var. *limitanea*: *Tracy & Earle 275* (BM, F, GH, MO, NY, US); Mex. Bound. Survey, *Parry et al.* (MO, NY); New Mexico, 1853, *Bigelow* (NY).

Exposed or sheltered rocky bluffs, cliffs and ledges, in crevices or soil pockets or usually covering rocks, on igneous rocks, sandstone or rarely limestone, 1450–4300 m.

Colorado and Utah to Texas and Arizona.

Representative specimens:

United States. colorado: 1874–1878, *Brandegee* (NY); *A. G. Compton* (NY); *I. M. Johnston 2423* (F, GH, NY, US); *M. A. C. Livermore* (NY); mountains of Colorado, 1871, *T. Meehan* (NY, YU); *E. J. Spence* (NY); *R. M. & A. F. Tryon 5071* (CU, MIN, MO, PH, POM, UC, US), *5072* (B, MO, US), *5073* (F, MO, NY, P, UC), *5075* (ARIZ, DS, FI, K, MICH, MO, RM); *E. P. Walker 365* (GH, NY, US). utah: *Graham 7592* (US), *10004* (US); *Maguire 18450* (GH). texas: 1921, *Goodding* (BM, GH, NY, US); *R. M. & A. F. Tryon 5083* (BM, GH, MO, US); *Waterfall 4811* (GH, MO, NY), *5392* (GH, MO, NY); *Wright 2115* (GH, NY). new mexico: *Arsène & Benedict 16643* (F, US); *Drouet & Richards 3311* (F, GH, MO, NY, US); *Standley 5199* (MO, NY, US). arizona: *Darrow 3631* (GH); 1896, *Toumey* (NY, US), 1894, *Toumey* (NY).



17. SELAGINELLA EXTENSA Underw. in Bull. Torr. Bot. Club 25:131. 1898. (Holotype: *Pringle 3900* NY. Paratype: *C. Müller* NY). Fig. 20. Map 27.

Selaginella rupestris mexicana Conzatti, Fl. Tax. Mex. 1:150. 1939, without Latin description, not var. *mexicana* Milde, 1867. (Based on *Pringle 3900*).

Plant terrestrial or sometimes epiphytic. Stems very long to long, branches long, remote, with the older primary branches once to twice pinnate; leafy stems radially symmetrical or nearly so. Leaves herbaceous, none red, subulate to ligulate-long-triangular to ligulate-lanceolate; base abruptly adnate, distinct from the stem in color, usually glabrous, sometimes pubescent; margins ciliate, the cilia dentiform, the longest cilia less than ¼ as long as the width of the blade; apical portion usually revolute; apex acuminate, rounded, plane or nearly so in profile; muticous, the apex subulate, greenish-hyaline. Sporophylls with the margins eciliate to short-ciliate toward the base; apex carinate. Megaspores finely rugose-reticulate on the commissural face, the equatorial region strongly and irregularly papillate, granular on the outer face, pale orange.

S. extensa is casually epiphytic and rather similar in habit to the pronounced epiphyte *S. oregana* of *Rupestres*. The revolute apical portion of many of the leaves, the muticous essentially unmodified leaf-apex, the habit and the unusual papillate megaspores combine to make this a very distinctive species.

On cliffs or in woods, covering limestone rocks or pendent from tree trunks, 870–1700 m.

Eastern Mexico and Jalisco.

Specimens examined:

Mexico. tamaulipas: *Sharp et al. 50255* (MO, US). san luis potosi: *McVaugh 10446* (US); *Pennell 17947* (US); Las Canoas, Aug. 21, 1891, *Pringle 3900* (F, GH, K, MO, US); *Sharp 46264* (US). veracruz: *Bourgeau 2541* (GH, YU); *Mohr 12* (YU); *Purpus 6052* (F, GH, MO, US); *Sharp 44168* (US). hidalgo: *T. C. & E. M. Frye 2537* (NY, US); *Hoogstraal & Chase 7308* (F, MO, US); *Kenoyer & Crum 3910* (GH); *Sharp 45864* (US). puebla: *Sharp 45375* (US). jalisco: *McVaugh 11829* (US).

18. Selaginella Wrightii Hieron. in Hedwigia 39:298. 1900. (Holotype: *Wright 828* B!). Fig. 21. Map 28.

Selaginella rupestris (L.) Spring f. *Wrightii* (Hieron.) Clute, in Fern Bull. 16:52. 1908.

Stems with the older primary branches once to twice pinnate; leafy stems usually strongly to rarely moderately dorsiventral in position, length and shape of the upper and under leaves. Upper leaves ligulate-long-triangular to long-triangular; apex acuminate to convexly acute. Under leaves herbaceous, none red, longer to only slightly longer than the upper, linear; apex acuminate, flat to slightly rounded, plane or nearly so in profile. All leaves with the base abruptly adnate, distinct from the stem in color, or the under leaves with the base rather decurrent, pubescent or glabrous; margins ciliate, the cilia piliform, or dentiform only toward the apex, the longest cilia ⅓ to ½ as long as the width of the blade; setae absent, the apex being hardly modified, or if present, arising very evenly in form and usually in color, rarely up to ⅓ as long as the blade, stout, whitish-lutescent to lutescent, translucent to opaque. Sporophylls with the margins long-ciliate toward the base; apex broadly rounded to carinate. Megaspores prominently rugose, pale to bright orange.

Of the definitely dorsiventral species of the series, S. *Wrightii* is the least dorsiventral. The linear under leaves, the long-ciliate sporophylls and the poorly differentiated setae are the primary characters of the species. This is the only species for which I have sufficient information to class definitely as a calciphile.

Exposed or shaded ledges and pockets of limestone, 800–2300 m.

Texas and New Mexico to southern Mexico.

Representative specimens:

United States. texas: *E. J. Palmer 11389* (GH, MO, NY, US); *Rose & Fitch 17973* (MO, NY, US); *Tharp 43-514* (MO, NY, US); *R. M. & A. F. Tryon 5034* (BM, GH, MO, P, US), *5035* (B, BM, F, GH, MO, NY, P, UC, US), *5037* (ARIZ, FI, GH, K, MO, RM, US); hills, Turkey Creek (near Cline, Uvalde Co.), June 25, 1849, *Wright 828* (B, GH, NY, US). new mexico: *Standley 40389* (GH, US).

Mexico. tamaulipas: *Bartlett 10561* (F, US). nuevo leon: *Barkley 16144M* (GH, MO); *Harvey 988* (GH, US); *C. H. Muller 2638* (GH, US). coahuila: *Johnston 8607* (GH, MO), *8854* (GH), *9106* (GH, MO, US). chihuahua: *Harvey 1507* (GH, US); *E. Palmer 455* in 1885 (GH, US, YU). san luis potosi: *A. A. Lundell 96* (US). zacatecas: *Lloyd & Kirkwood* (or *Kirkwood*) *20* (MO, US), *142* (GH, MO). hidalgo: *Kenoyer 1053* (GH). puebla: *E. B. Copeland 174* (US). guerrero: *Hinton 9678* (GH, US). oaxaca: *Pringle & Conzatti 1390* (GH).

19. SELAGINELLA STEYERMARKII Alston, in Ann. & Mag. Nat. Hist., XII, 7:638. 1954. (Holotype: *Steyermark 50501* BM!. Paratypes: *Steyermark 47115* BM!, *51292* BM!). Figs. 22, 23. Map 29.

Stems with the older primary branches once to twice pinnate; leafy stems strongly dorsiventral in position, length and shape of the upper and under leaves. Upper leaves subulate to subulate-long-triangular; apex long-acuminate. Under leaves papyraceous to herbaceous-papyraceous, usually some red, longer than the upper, subulate-lanceolate to ligulate-lanceolate; apex long-acuminate, flat or very slightly rounded, plane in profile. All leaves with the base abruptly adnate, distinct from the stem in color, pubescent to rarely glabrous; margins ciliate, cilia piliform, the longest cilia ¼ to ½ as long as the width of the blade; setae usually arising evenly in form and abruptly in color, ¼ to ⅓ as long as the blade, slightly to strongly attenuate, white to whitish-lutescent, translucent to subopaque. Sporophylls with the margins eciliate to short-ciliate toward the base; apex rounded to carinate. Megaspores finely to moderately rugose-reticulate, to nearly smooth on the outer face, more prominently and coarsely marked in the equatorial region, pale orange.

This species and the next, S. *Hansenii*, are the only ones that usually have some red leaves on the stem. In S. *Sartorii* such leaves are present infrequently. They tend to occur particularly among the oldest living leaves and the youngest dead ones and often are more common on the under side of the stem.

The long-acuminate apex of the upper leaves and the thin under leaves afford an ample separation from S. *Hansenii*. This species has the most robust leafy stems of any in the series and material collected in the growing state presents particularly attractive sprays. It is one of the very few species I know to be casually cultivated; the Standley collection cited below was from the garden of Mariano Pacheco.

Rocks and banks, 1630–2000 m.

Guatemala and adjacent Mexico.

Specimens examined:

MEXICO. CHIAPAS: *Matuda 1846* (US).

GUATEMALA: *Aguilar 1429* (F, US); *Hatch & Wilson 283* (US), *325* (US); *Haupt 105* (US); *Maxon & Hay 3410* (US); *Standley 63102* (F, US); *Steyermark 47115* (BM), between San Sebastián Hacienda and large peñasco above town, Dept. Huehuetenango, 2000–2200 m., 1942, *Steyermark 50501* (BM), *Steyermark 51292* (BM); *Tuerckheim 8844* (GH, US); *L. O. Williams 14299* (US).

20. SELAGINELLA HANSENII Hieron. in Hedwigia 39:301. 1900, as *Hanseni;* maintained over S. *Bolanderi*. (Lectotype: *Hansen 878* B!. Paratypes: *Hillebrand* B!; *A. A. Eaton* B!). Fig. 24. Map 30.

Selaginella Bolanderi Hieron. in Hedwigia 39:300. 1900. (Holotype: *Bolander 4511* B! fragment NY!).

Selaginella rupestris (L.) Spring f. *Hansenii* (Hieron.) Clute, in Fern Bull. 16:52. 1908.

Selaginella rupestris f. *Bolanderi* (Hieron.) Clute, in Fern Bull. 16:52. 1908.

Selaginella rupestris var. *Hansenii* (Hieron.) Jepson, Man. Pl. Calif. 42. 1923.

Selaginella rupestris var. *Bolanderi* (Hieron.) Jepson, Man. Pl. Calif. 42. 1923.

Stems with the older primary branches once to usually twice to rarely three times pinnate; leafy stems strongly dorsiventral in position, length and shape of the upper and under leaves. Upper leaves long-triangular to ligulate to lanceolate-long-triangular; apex convexly acute to acute. Under leaves herbaceous, usually some red, longer than the upper, linear-lanceolate to lanceolate; apex convexly acute to acuminate, flat to slightly rounded, plane to gently beveled in profile. All leaves with the base abruptly adnate, distinct from the stem in color, glabrous or pubescent; margins ciliate, the cilia piliform, or dentiform only toward the apex, the longest cilia ¼ to rarely nearly ½ as long as the width of the blade; setae arising rather abruptly in form and in color, ⅕ to nearly ½ as long as the blade, stout to attenuate, milk-white to whitish, translucent to opaque. Sporophylls with the margins eciliate to short-ciliate toward the base; apex broadly rounded to carinate. Megaspores rugose to rugose-reticulate on the commissural face, less prominently rugose-reticulate to smooth on the outer face, with an equatorial ring, lemon-yellow.

S. *Hansenii* is related to the previous species, S. *Steyermarkii*, by the dorsiventral leafy stem and the commonly occurring red leaves. These characters, however, may be the result of parallel evolution. The red leaves tend to be more common on the under side of the stem and in the area where living and dead leaves adjoin.

The branches at the center of a mat tend to be rather erect and compact, those on the periphery prostrate, long-creeping and remote. This variation within a mat, together with its associated characters of number and spacing of the leaves, is similar to that found in S. *tortipila* of *Arenicolae*.

Open or lightly shaded bluffs or cliffs and surfaces of igneous rocks, 330–1350 m.

Central California.

Representative specimens:

UNITED STATES. CALIFORNIA: Auburn, Placer Co., April 10, 1865, *Bolander 4511* (B, MO, NY, US); 1892, *A. A. Eaton* (B, NY); Fisher's Cabin, Mokelumne River, Amador and Calaveras counties, April, 1893, *G. Hansen 878* (B, MO, NY, US); *Heller 2583* (F, GH, MO, NY, US), *5466* (GH, MO, NY, US), *8173* (F, GH, MO, NY, US), *10715* (GH, MO, US), *11802* (F, GH, MO, US); 1863, *Hillebrand* (B); *R. M. & A. F. Tryon 5067* (ARIZ, B, BM, CU, DS, F, FI, GH, K, MICH, MIN, MO, NY, P, POM, RM, UC, US, WS).

21. SELAGINELLA **carinata** Tryon, spec. nov. Figs. 25, 26. Map 31.

Caules breves, ramis brevibus propinquis; caules frondosae positione foliorum superorum et inferorum valde dorsiventrales sed forma minus. Folia carnosa, apice carinato vel valde carinato, aspectu laterali truncato vel abrupte declivi, base abrupte adnata cum caule distincta colore, setis abrupte productis colore sensim diversis. Sporophylla marginibus ad basem eciliatis. Megasporae laeves flavae. Typus: *Rose, Pachano & Rose 23039* (US).

Stems short; branches short, approximate; older primary branches once to usually twice, sometimes three times pinnate; leafy stems strongly dorsiventral in position and less so in the shape of the upper and under leaves. Upper leaves

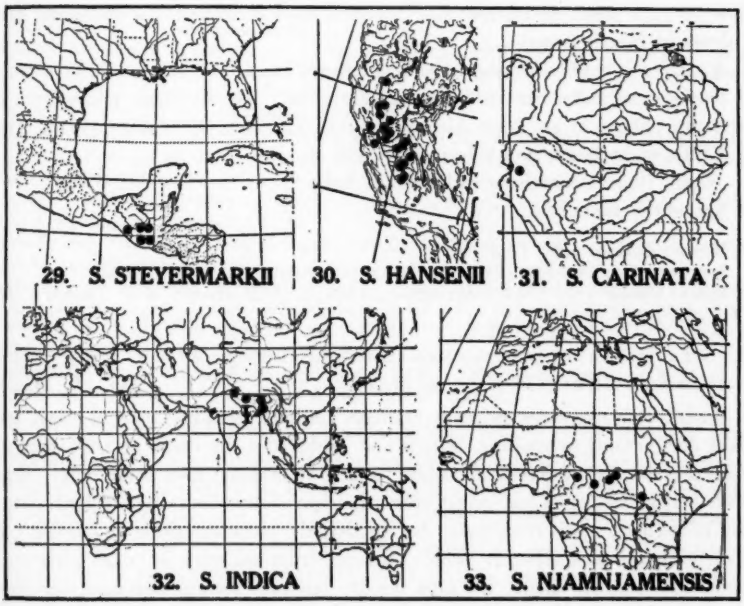
ligulate-long-triangular; apex convexly acute. Under leaves fleshy, none red, lanceolate to ligulate-lanceolate; apex acuminate to convexly acute, carinate to strongly carinate, truncate to abruptly beveled in profile. All leaves with the base abruptly adnate, distinct from the stem in color, glabrous; margins ciliate, the cilia piliform toward the base, dentiform above, the longest cilia ¼ or less as long as the width of the blade; setae arising abruptly in form and evenly in color, ¼ to ½ as long as the blade, rather stout at the base, tapering evenly to the tip, greenish- to lutescent-whitish and subopaque at the base, milk-white and opaque toward the tip. Sporophylls with the margins eciliate toward the base; apex strongly carinate. Megaspores smooth, yellow.

S. carinata is a distinctive species and not evidently related to any others. The very short stems and branches and the fleshy leaves with carinate and truncate apex set it off from the other species of this series. Some strobili are slightly dorsi-ventral, particularly toward the base, apparently a development parallel to that in the African and Madagascar species.

Central Ecuador.

Specimens examined:

ECUADOR: Vicinity of Nabón, Sept. 26, 1918, *Rose, Pachano & Rose 23039* (GH, US).



22. Selaginella **indica** (Milde) Tryon, comb. nov. Fig. 27. Map 32.

Selaginella rupestris (L.) Spring f. *indica* Milde, Fil. Europ. Atlant. 262. 1867. (Holotype: *Hooker f. & Thomson*).

Selaginella longipila of authors, not Hieron., for example, of Alston, in Proc. Nat. Inst. Sci. India 11:214. 1945.

Stems with the older primary branches once to twice pinnate; leafy stems strongly dorsiventral in position, length and shape of the upper and under leaves. Upper leaves subulate-long-triangular to long-triangular; apex acuminate. Under leaves papyraceous, none red, longer than the upper, long-triangular to ligulate-long-triangular to subulate-lanceolate; apex acuminate, flat, plane in profile. All leaves with the base abruptly adnate, distinct in color, glabrous to slightly pubescent; margins ciliate, the cilia piliform toward the base, dentiform above, the longest cilia ¼ to ½ as long as the width of the blade; setae usually arising evenly in form, less so in color, ¼ as long as the blade, strongly attenuate, tawny to lutescent-whitish, translucent. Sporophylls with the margins eciliate to short-ciliate toward the base; apex rounded to carinate. Megaspores rather finely rugose-reticulate on the commissural face, less prominently marked on the outer face, pale orange.

This species was known as S. *longipila* from the time of the description of that species by Hieronymus, since the specimens were cited as from the Himalayas. However, the labels on Hieronymus' material were erroneous, the specimens being S. *densa* of North America.

S. *indica* is readily distinguished from the other Indian species, S. *Wightii*, by its dorsiventral leafy stem and thin under leaves. The localities taken from the literature (Map 32) are from Alston, in Proc. Nat. Inst. Sci. India 11:214. 1945.

Cliffs, rocky banks and ledges, 700–2800 m.

Nepal, Bhutan, northern and western India.

Specimens examined:

Nepal: *Polunin 1478* (BM).
Bhutan: *Griffith 2871* (BM); *Ludlow et al. 17039* (BM), *18606* (BM).
India: *Duthie 3727* (BM, US); Khasia, 5000 ft., *J. D. Hooker & T. Thomson* (GH, NY, P, YU).

23. Selaginella njamnjamensis Hieron. in Hedwigia 39:312. 1900. (Holotype: *Schweinfurth* B! fragment NY!). Fig. 28. Map 33.

Stems with the older primary branches once to usually twice pinnate; leafy stems dorsiventral in position, length and slightly in the shape of the upper and under leaves. Upper leaves lanceolate to long-triangular; apex acuminate. Under leaves herbaceous, none red, longer than the upper, linear-lanceolate to lanceolate to long-triangular; apex acuminate, flat to slightly rounded, plane in profile. All leaves with the base abruptly adnate, distinct from the stem in color, glabrous to pubescent; margins ciliate, the cilia usually piliform toward the base, dentiform above, the longest cilia ¼ to nearly ½ as long as the width of the blade; setae arising evenly in form and color, ¼ or less as long as the blade, stout to attenuate,

tawny to lutescent-whitish, subopaque to opaque. Sporophylls on the upper side of the strobilus lanceolate, acuminate, on the under side ovate-long-triangular to narrowly ovate, acuminate, slightly longer and broader; margins short-ciliate toward the base; apex broadly rounded to carinate. Megaspores granular to granular-tuberculate, yellow.

This species is the least dorsiventral of the related species in Africa and Madagascar. Although sufficiently distinct from S. *caffrorum*, both species tend to overlap in the range of variation of the individual characters. The herbaceous under leaves with the base abruptly adnate and distinct in color and the poorly differentiated setae are the primary characters of S. *njamnjamensis*.

On and between exposed rocks, 800–1200 m.

Central and southeastern Africa.

Specimens examined:

ANGLO-EGYPTIAN SUDAN: *Dandy 510* (BM); *Hoyle 520* (BM).
FRENCH EQUATORIAL AFRICA: *Chevalier 6668* (BM,P); *Le Testu 4794* (BM); *Tisserant 3587* (BM).
CENTRAL AFRICA: Njam-Njam, 1870, *Schweinfurth* (B, K, NY, P).
PORTUGESE EAST AFRICA: *Sim 6095* (P).

24. SELAGINELLA CAFFRORUM (Milde) Hieron. in Hedwigia 39:313. 1900. Fig. 29. Map 34.

Selaginella rupestris (L.) Spring f. *caffrorum* Milde, Fil. Europ. Atlant. 262. 1867. (Holotype: Terra Caffrorum, *Bunge*).
Selaginella rupestris var. *incurva* A. Br. in Kuhn, Fil. Afr. 213. 1868, category taken from annotation of *Welwitsch 169* by A. Br. (Lectotype: *Drège, Lycopodium rupestre a* B. Paratypes: *Ecklon & Zeyher 7* B; *Drège, Lycopodium rupestre aa* B; *Welwitsch 169* B!; *Quartin-Dillon; Steudner*).
Selaginella rupestris var. *incurva* f. *abyssinica* A. Br. in Kuhn, Fil. Afr. 213. 1868, nomen nudum. A single description was provided for "forma capensis et abyssinica". I have seen *Quartin-Dillon*, P, but not *Steudner*, the other specimen cited.
Selaginella rupestris var. *incurva* f. *angolensis* A. Br. in Kuhn, Fil. Afr. 213. 1868. (Holotype: *Welwitsch 169* B!).
Selaginella rupestris var. *incurva* f. *capensis* A. Br. in Kuhn, Fil. Afr. 213. 1868, nomen nudum (see f. *abyssinica*).
Selaginella capensis Hieron. in Hedwigia 39:314. 1900, epithet from S. *rupestris* f. *capensis* A. Br. (Lectotype: *Drège, Lycopodium rupestre a* B. Paratypes: *Ecklon & Zeyher 7* B; *Drège, Lycopodium rupestre aa* B; *R. Baur 1110* B; *Sonder* B!; *Goldschmid* B; *Rehmann 3924* B, *4005* B; *Sutherland* B).
Selaginella Quartiniana Cufodontis, in Phyton 4:178. 1952, nomen nudum, based on S. *rupestris* var. *incurva* f. *abyssinica* A. Br., nomen nudum.

Stems with the older primary branches once to usually twice to rarely three times pinnate; leafy stems dorsiventral in position, length and shape of the upper and under leaves. Upper leaves linear-long-triangular to ligulate-long-triangular; apex acuminate to convexly acute. Under leaves papyraceous to papyraceous-herbaceous, none red, longer than the upper, lanceolate to ligulate-lanceolate to triangular; apex acuminate to convexly acute, flat to slightly rounded, plane or nearly so in profile. All leaves with the base abruptly adnate, distinct from the

stem in color, or the under leaves with the base slightly decurrent and blending in color, glabrous or rarely pubescent; margins ciliate, the cilia piliform, or sometimes dentiform toward the apex, the longest cilia ¼ to ½ as long as the width of the blade; setae arising rather abruptly in form and color, ¼ to ½ as long as the blade, rather stout, whitish to whitish-tawny or whitish-lutescent, translucent to subopaque. Sporophylls on the upper side of the strobilus ovate-lanceolate to long-triangular, on the under side lanceolate-ovate to broadly ovate, acuminate, longer and broader; margins short- to long-ciliate toward the base; apex rounded to carinate. Megaspores rugose-reticulate to granular-rugose on the commissural face, more finely and less prominently marked on the outer face, lemon-yellow.

The thin under leaves and well-differentiated setae are characteristic of *S. caffrorum* and set it off from the related *S. njamnjamensis*. In addition, *S. caffrorum* usually has some of the under leaves on the main stem with decurrent bases.

Dry or moist rocky places, 600–2000 m.

Anglo-Egyptian Sudan to Angola and Union of South Africa.

Specimens examined:

Anglo-Egyptian Sudan: *Jackson 1116* (BM); *MacLeay 114* (BM).
Tanganyika: *Greenway 2431* (BM).
Angola: *Antunes 543* (P); *Dekindt 543* (K, P); Lopolo, Huilla, 5000 ft., April, 1860, *Welwitsch 169* (B, K, NY, P).
Union of South Africa. Natal: *Rudatis 857* (P). Orange Free State: *Rehmann 3924* (P), *3949* (NY, P). Basutoland: *Dieterlen 117* (P). Cape of Good Hope: *T. Cooper 662* (NY); Katberg, 4000–5000 ft., *Lycopodium rupestre a, Drège* (GH, K, P, US); *Ecklon & Zeyher* (B, P); *Sonder* (B).

25. Selaginella echinata Baker, in Jour. Linn. Soc. 22:536. 1887. (Holotype: *Baron 4226* K!). Figs. 30, 31. Map 35.

Stems with the older primary branches once to three times, usually twice, pinnate; leafy stems dorsiventral in position, length, shape and in setae characters of the upper and under leaves. Upper leaves ligulate-long-triangular; apex acute; setae arising abruptly, mostly soon deciduous, usually substellate, divided into two to several filiform branches, whitish, translucent to opaque. Under leaves herbaceous-papyraceous, none red, longer than the upper, ovate-lanceolate; apex acuminate, flat to slightly rounded, plane in profile; setae arising very evenly in form and color, ¼ or less as long as the blade, persistent, stout, lutescent to tawny, opaque to subopaque. All leaves with the base adnate to abruptly adnate, distinct from the stem in color, glabrous; margins ciliate, the cilia piliform, the longest cilia ¼ to usually ½ as long as the width of the blade. Sporophylls on the upper side of the strobilus broadly ovate-lanceolate, obtuse, on the under side very broadly ovate-triangular, acuminate, longer and broader; margins long-ciliate toward the base; apex broadly rounded to carinate. Megaspores tuberculate, yellow.

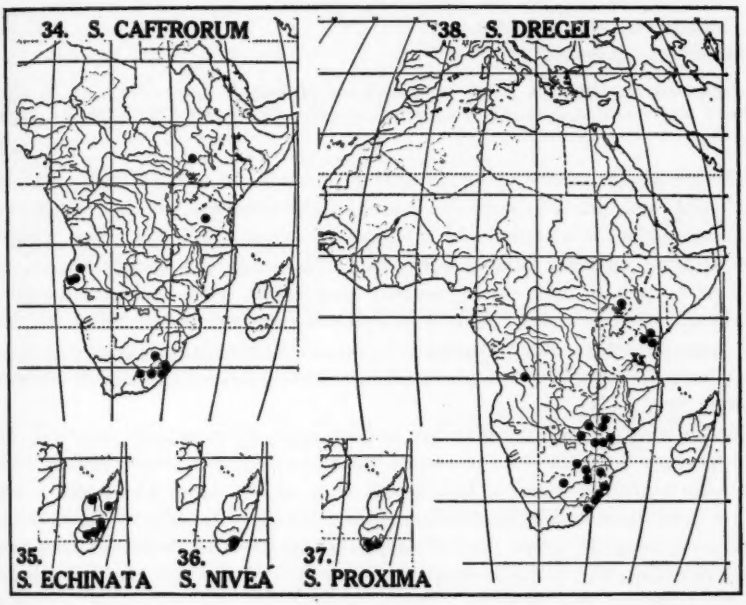
S. echinata is the most distinctive of the three species of Madagascar. It is the most strongly dorsiventral species and in addition has the truly unique character of substellate setae on the upper leaves. Also some leaves and sporophylls have

a unique whitish to tawny, long-appressed pubescence on the back, which among the specimens I have seen is most pronounced in *Perrier 8262*.

Madagascar, 500–2000 m.

Specimens examined:

MADAGASCAR: *Baron 4226* (BM, K); 1879, *Cowan* (BM); *Humbert 2823* (P), *3000* (P), *3538* (P), *11778* (P); *Humbert & Swingle 4791* (P); *Perrier 1168* (P), *8261* (P), *8262* (BM, P), *8311* (BM, P), *8312* (P), *8313* (BM, P), *8324* (P), *8346* (BM, P).



26. SELAGINELLA NIVEA Alston, in Perrier, Cat. Pl. Madagascar, 71. Feb. 1932, nomen nudum; in Dansk Bot. Ark. 7 (C. Chr., Pterid. Madagascar):194. June, 1932. (Holotype: *Perrier 8303* BM!. Paratype. *Perrier 8305* BM!).

Fig. 32. Map 36.

Stems with the older primary branches once to twice pinnate; leafy stems dorsiventral in position and shape of the upper and under leaves. Upper leaves linear-lanceolate to lanceolate; apex acute to acuminate. Under leaves papyraceous, none red, triangular to ligulate-triangular; apex acute to acuminate, flat to slightly rounded, plane in profile. All leaves with the base abruptly adnate, distinct from the stem in color, glabrous; margins ciliate, the cilia piliform toward the base, dentiform above, the longest cilia ¼ or less as long as the width of the blade; setae arising evenly in form, abruptly in color, ¼ to ⅓ as long as the blade, stout, milk-white, opaque. Sporophylls on the upper side of the strobilus lanceolate-ovate, on the under side broadly ovate, acuminate, longer and broader; margins long-

ciliate toward the base; apex broadly rounded to carinate. Megaspores finely granular to nearly smooth, light yellow-orange.

This species has a remarkable superficial resemblance to S. *cinerascens* although in technical characters there is no relationship between them. S. *nivea* may be separated from the next species, S. *proxima*, by the straight and relatively short setae in addition to the characters of habit. S. *nivea* is closely prostrate with the branches once or twice divided. S. *proxima* has the primary branches tending to be ascendent and dendroid and commonly three, rarely four, times divided.

Madagascar, among bushes.

Specimens examined:

MADAGASCAR: *Humbert 11612* (P); *Humbert & Swingle 5518* (BM, GH, P, US); vicinity of Ampanihy, June, 1910, *Perrier 8303* (BM, P), *Perrier 8305* (BM, P), *18702* (P).

27. SELAGINELLA **proxima** Tryon, spec. nov. Figs. 33–35. Map. 37.

Caules ramis primariis saepe dendroideis; caules frondosae positione longitudine et forma foliorum superorum et inferorum dorsiventrales. Folia base abrupte adnata caule distincta colore, marginibus ciliis longissimis longitudine ¼–½ laminae latitudinis, setis ⅓–½ laminae longitudinis valde curvatis juventate praesertim cretaceis caecis. Strobili dorsiventrales sporophyllis stichorum duorum dorsalium deltoideis duorum ventralium ovato-deltoideis longioribus et latioribus. Megasporae leviter rugoso-reticulatae vel laeves citreo-flavae. Typus: *Humbert & Swingle 5705* (US).

Stems with the primary branches tending to be ascendent and dendroid, the older primary branches twice to usually three to rarely four times pinnate; leafy stem dorsiventral in position, length and shape of the upper and under leaves. Upper leaves lanceolate to ligulate-lanceolate; apex acute to obtuse. Under leaves herbaceous, none red, longer than the upper, triangular to ligulate-lanceolate; apex acute to obtuse, flat, plane in profile. All leaves with the base abruptly adnate, distinct from the stem in color, glabrous to pubescent; margins ciliate, cilia piliform, the longest cilia ¼ to ½ as long as the width of the blade; setae arising evenly to abruptly in form, abruptly in color, ⅓ to ½ as long as the blade, stout at the base, usually with a filiform tip, strongly curved, especially those of the branch-tips, milk-white, opaque. Sporophylls on the upper side of the strobilus deltoid to long-deltoid, on the under side ovate-deltoid, longer and broader; margins short- to long-ciliate toward the base; apex broadly rounded to carinate. Megaspores very slightly rugose-reticulate to smooth, lemon-yellow.

The strongly curved setae suggest a relationship to S. *Dregei* while in other characters S. *proxima* is more closely related to the preceding species, S. *nivea*. The differences are discussed under that species.

A bush xerophile, 20–1200 m.

Madagascar.

Specimens examined:

MADAGASCAR: *Humbert 6557* (P), *7089 bis* (P), *12439* (P), *12706* (P), *13338* (P), *14158* (P); *Humbert & Swingle 5581* (P), vicinity of Fort Dauphin, near Bevilany, 200–300 m., Sept. 14, 1928, *Humbert & Swingle 5705* (GH, P, US).

28. SELAGINELLA DREGEI (Presl) Hieron. in Hedwigia 39:315. 1900.

Fig. 36. Map 38.

Lycopodium Dregei Presl, in Abhandl. Böhm. Gesell. Wissen. V, 3 (Bot. Bermerkungen): 583, reprint 153. 1844. (Holotype: *Drège, Lycopodium rupestre b* PRC. *Drège, Lycopodium rupestre a* is excluded as a type; it is *S. caffrorum*).

Selaginella rupestris (L.) Spring f. *Dregei* (Presl) Milde, Fil. Europ. Atlant. 262. 1867.

Selaginella rupestris var. *recurva* A. Br. in Kuhn, Fil. Afr. 213. 1868, category taken from annotation of *Welwitsch 48* and *Drège, Lycopodium rupestre b* by A. Br. (Lectotype: *Drège, Lycopodium rupestre b* B!. Paratypes: *Welwitsch 48* B!, *49* B).

Selaginella rupestris var. *recurva* f. *Dregeana* A. Br. in Kuhn, Fil. Afr. 214. 1868, based on *Lycopodium Dregei* Presl as to *Drège, Lycopodium rupestre b.*

Selaginella rupestris var. *recurva* f. *Welwitschiana* A. Br. in Kuhn, Fil. Afr. 214. 1868: (Lectotype: *Welwitsch 48* B!. Paratype: *Welwitsch 49* B).

Selaginella Dregei var. *pretoriensis* Hieron. in Hedwigia 39:317. 1900. (Lectotype: *Rehmann 4333* B!. Paratype: *Wilms 1814* B).

Selaginella Dregei var. *Rehmanniana* Hieron. in Hedwigia 39:317. 1900. (Lectotype: *Rehmann 5576* B!. Paratype: *Braga 98* B).

Selaginella Dregei var. *Bachmanniana* Hieron. in Hedwigia 39:317. 1900. (Holotype: *Bachmann 9* B!).

Selaginella Dregei var. *Petersiana* Hieron. in Hedwigia 39:317. 1900. (Holotype: *Peters* B!).

Selaginella Dregei var. *Hildebrandtiana* Hieron. in Hedwigia 39:317. 1900. (Lectotype: *Hildebrandt 2363* B!. Paratypes: *Fischer 627* B, fragment NY!; *Stuhlmann 910* B, *4305* B).

Selaginella Dregei var. *Welwitschiana* (A. Br.) Hieron. in Hedwigia 39:318. 1900.

Selaginella grisea Alston, in Jour. Bot. 77:222. 1939, based on *S. Dregei* var. *Hildebrandtiana* Hieron.

Stems often irregularly ascendent, buds rarely present at the base of the branches, older primary branches once to twice, rarely three times, pinnate; leafy stems radially symmetrical to somewhat dorsiventral in position and sometimes also in shape of the upper and under leaves. Leaves herbaceous to herbaceous-papyraceous, none red, subulate to long-triangular to ligulate-long-triangular; base abruptly adnate, distinct from the stem in color, glabrous; margins ciliate, the cilia piliform, the longest cilia ½ as long to as long as the width of the blade; apex acuminate to long-acuminate, flat to slightly rounded, plane in profile; setae arising evenly in form and usually in color, ⅓ to usually ½ as long to as long as the blade, attenuate, usually strongly curved, especially those of the growing-points, milk-white and opaque to rarely tawny-whitish, subopaque. Sporophylls in 2 ranks on the under side of the branch-tip; margins eciliate to long-ciliate toward the base; apex broadly rounded. Megaspores slightly tuberculate on the commissural face, similar to slightly rugose on the outer face, with an equatorial ridge, yellow to orange.

The unilateral strobilus of this species is one of the most unique characters of any in the section. There are two rows of sporophylls on the under side of the

branch tip while vegetative leaves replace the usual two rows on the upper side. This character is sufficient to identify the species in spite of considerable variation in other characters such as the color, length and degree of curving of the setae, the leaf shape, the symmetry of the leafy stem, the number and length of the cilia on the leaves and the shape of the sporophylls. Except that the dorsiventral specimens have the broader under leaves, none of the variations correlate with each other or with a coherent distribution.

Some sterile material with straight setae such as *Peters*, Mozambique, is difficult to place. However, such specimens as *Moss 18988* BM which is otherwise similar, are fertile and can be placed with certainty.

S. *Dregei* is variable in habit, the stems varying from closely prostrate to loosely and irregularly ascending. In the latter case the rhizophores may be unusually long. Rarely, some stems will have short branches at the base which will actively grow upon the death of the portions above. This character is otherwise found only in *Arenicolae* where it is well developed and constant in such species as S. *rupincola* and S. *arenicola*.

The localities taken from the literature (Map 38) are from Alston, in Jour. Bot. 77:222. 1939.

Exposed or sheltered rocky places, on or among igneous or sandstone rocks, 700–2300 m.

Southern and eastern Africa.

Representative specimens:

Uganda: *Eggeling 2619* (US).

Kenya: *Fischer 627* (B, NY); Egu, between Duruma and Taita, Jan. 1877, *Hildebrandt 2363* (B, BM, K, NY, P).

Portugese East Africa (Mozambique): *Gomes & Sousa 85* (BM); *Peters* (B).

Rhodesia: *Munro 1777* (BM, P, US), *1883* (BM); *Rodin 4403* (MO, US).

Angola: *Exell & Mendonca 169* (BM); Pedras de Guinga, Pungo Andongo, 3800 ft., March, 1837, *Welwitsch 48* (B, K, P).

Bechuanaland: *Burchell 2315* (GH).

Union of South Africa. transvaal: *Leendertz 935* (BM, P), *2568* (F); Aapies-river, Pretoria, *Rehmann 4333* (B, K), Houtbosh, *Rehmann 5576* (B, K); *Wilms 1814* (NY, P). natal: Omsamcaba, 1844, *Lycopodium rupestre b, Drège* (B, K, P); *W. T. Gerrard* (P); *J. M. Wood 11950* (F). orange free state: *Rehmann 3949* (P). cape of good hope: Pondoland, 1887–88, *Bachmann 9* (B, P).

Series **Rupestres** Tryon, ser. nov.

Rhizomata et stolones nulla, gemmae breves simplices ad bases caulium rare praesentes vel absentes. Caules prostrati, ramis rare pendulis. Apices ramorum recti vel leviter curvati statu inerte. Caules frondosi leviter dorsiventrales vel radialiter symmetricales. Folia base decurrente vel valde decurrente. Typus: *Selaginella rupestris* (L.) Spring.

Plants terrestrial or, in S. *oregana*, usually epiphytic; rhizomes and stolons absent, short, simple basal buds absent or, in S. *oregana*, occasionally present. Stems prostrate with rhizophores produced generally throughout or, in S. *oregana*,

the branches usually pendent with rhizophores only on the prostrate main stems. Branches straight or slightly curled in the dormant state or, in S. *oregana*, strongly curled; branch tips straight or slightly curved in the dormant state. Leafy stems radially symmetrical, the leaves equal in position, length and shape on all sides on the same portion of the stem, or dorsiventral in position, the under leaves loosely appressed, the upper erect-ascending, and sometimes also in length, the under slightly longer than the upper; zone of green leaves equal or nearly equal on all sides of the stem. Leaf-bases strongly decurrent on all sides of the stem or those on the upper side decurrent. Setae of the sporophylls terete or oval at the base or often, in S. *densa* and S. *sibirica*, with the base strongly broadened and flattened. Megaspores 4 in a megasporangium; rarely 1–2, or in S. *rupestris* commonly 1–2.

The *Rupestres* is a rather homogeneous series. Although the species are sufficiently distinctive they do not differ from each other by as many characters as the members of the other series. The last three species, S. *utahensis*, S. *leucobryoides* and S. *asprella*, share the peculiar character of easily fragmenting stems and this is also present, although to a lesser degree, in S. *Watsonii*. These four species form the only definite group within the series. S. *Vardei*, with some of the leaves rarely with abruptly adnate bases, may illustrate a transition from *Arenicolae*. The dorsiventral S. *densa* appears to be an example of parallel evolution and not related by that character to *Eremophilae* or the dorsiventral *Sartorii*. S. *rupestris* is notable for its development of apogamy and S. *densa* and S. *sibirica* rarely show a tendency toward such a development.

KEY TO SPECIES

a. Dry leafy stems persistently whole, not fragmenting; stems forming cushion mats with discrete branches, *or* spreading mats with intricate branches, *or* pendent, forming festoons, *or* if forming cushion mats with intricate branches then the apex of the upper leaves fleshy. b.

b. Stems forming flat mats with discrete branches *or* spreading mats with intricate branches, *or* pendent, forming festoons; apex of the upper leaves herbaceous to slightly fleshy, plane to abruptly beveled in profile; *or* if the apex of the upper leaves fleshy and truncate in profile then the setae of the leaves ⅓ to over ½ as long as the blade and the broadest sporophylls about 4 times as broad as the leaves. c.

c. Stems elongate, branches long and remote, intricate; apex of the upper leaves plane in profile; broadest sporophylls about 4 times as broad as the leaves. China ..... 29. S. *Vardei*, p. 61

c. Stems short, the branches short, approximate, discrete; *or* the apex of the upper leaves beveled to truncate in profile; *or* the broadest sporophylls about 2 times as broad as the leaves. d.

d. Plants usually epiphytic, the stems pendent with rhizophores only at or near the base; leaves adnate to the stem for ¼ to usually ⅓ to nearly ½ their length; branches strongly curled in the dormant state. Coastal Washington to northern California ..... 30. S. *oregana*, p. 61

d. Plants terrestrial, usually with rhizophores throughout; upper leaves adnate to the stem for 1/5 to rarely 1/4 their length; branches not or slightly curled in the dormant state. e.

e. Apex of upper leaves nearly plane to abruptly beveled in profile, *or* if truncate then the setae lutescent and the stems forming compact flat mats with discrete branches. f.

f. Upper and under leaves essentially or quite equal in length on the same portion of the stem; stems forming open, spreading mats with intricate branches; base of setae of the sporophylls not or slightly broadened and flattened. g.

g. Broadest sporophylls about 2 times as broad as the leaves; sporophylls and leaves eciliate or with cilia strongly ascending and dentiform toward the apex. Texas to Arizona, north to Wyoming ..... 31. S. *Underwoodii*, p. 62

g. Broadest sporophylls about 4 times as broad as the leaves; sporophylls and leaves with cilia spreading to laxly ascending and piliform toward the apex. Georgia to Greenland, west to Arkansas, Nebraska and Alberta ..... 32. S. *rupestris*, p. 64

f. Upper and under leaves unequal in length on the same portion of the stem, the under definitely longer; stems forming compact mats with discrete branches; base of setae of the sporophylls often strongly broadened and flattened. Texas to Arizona; California; north to Saskatchewan, Alaska and British Columbia ..... 33. S. *densa*, p. 66

e. Apex of the upper leaves truncate in profile; setae white to tawny; stems forming open, spreading mats with intricate branches. Yukon to Siberia and Japan ..... 34. S. *sibirica*, p. 71

b. Stems forming rounded cushion mats with intricate branches; apex of the upper leaves fleshy, truncate or subtruncate in profile; setae of the leaves 1/5 to 1/4, rarely 1/3, as long as the blade; broadest sporophylls about 2 times as broad as the leaves. California to Oregon and Montana ..... 35. S. *Watsonii*, p. 72

a. Dry leafy stems readily fragmenting; stems forming cushion mats with usually intricate branches; apex of the upper leaves herbaceous to slightly fleshy. Southwestern Utah to southern California. h.

h. Setae not forming a conspicuous tuft at the growing-tip, 1/5 or less as long as the blade. i.

i. Setae essentially absent or, if present, then smooth, whitish to greenish- or lutescent-whitish, subopaque. Southwestern Utah and southeastern Nevada ..... 36. S. *utahensis*, p. 74

i. Setae scabrous, white, usually opaque. Southeastern California ..... 37. S. *leucobryoides*, p. 74

h. Setae forming a conspicuous tuft at the growing-tip, ⅓ to more than ½ as long as the blade, scabrous, white, usually translucent. Southern California ..... 38. S. *asprella*, p. 75

29. SELAGINELLA VARDEI Lév. Cat. Pl. Yun-Nan, 172. 1917. (Holotype: *Maire 56* E). Fig. 37. Map 39.

Stems long, forming open, spreading mats; branches long, remote, intricate, not fragmenting when dry. Upper and under leaves about equal in length on the same portion of the stem; leaves subulate to subulate-long-triangular; base pubescent, that of the upper leaves adnate to the stem for ¼ or less their length; margins ciliate, the cilia strongly ascending toward the apex of the blade; apex of the upper leaves herbaceous, flat to slightly rounded, plane or nearly so in profile; setae forming conspicuous tufts at the dry branch-tips, ⅓ to ½ as long as the blade, usually slightly scabrous, tawny to whitish-tawny, translucent. Sporophylls with the cilia dentiform and ascending toward the apex, the broadest about 4 times as broad as the leaves. Megaspores unknown.

On the basis of its generalized characters, this species is placed as the most primitive in the series. One specimen examined had several of the leaves abruptly adnate and distinct in color at the base, characters of the previous series, *Sartorii*.

In the material examined only microsporangia were found and these occurred in the basal sporophylls as well as those above. The explanation of this in terms of the reproduction of the species is not clear. It suggests that the stems may be monoecious or dioecious but fertilization would be extremely unlikely under such circumstances. The localities taken from the literature (map 39) are from Alston, in Bull. Fan Mem. Inst. 5:267. 1934.

Exposed rocky places, 1500–3800 m.

Szechwan, Yunnan and Tibet.

Specimens examined:

CHINA. SZECHWAN: *H. Smith 2394* (BM); *E. H. Wilson 5411* (P). YUNNAN: *J. W. & C. J. Gregory* (BM); Siao-ou-long, 2900 m., Oct. 1912, *Maire 56* (BM). TIBET: *Ludlow et al. 4116* (BM), *5494* (BM), *14233* (BM).

30. SELAGINELLA OREGANA D. C. Eaton, in Wats. Bot. Calif. 2:350. 1880. (Lectotype by Weath. in Jour. Arn. Arb. 25:411. 1944: *Kautz* YU!. Paratype: *Summers 2209* YU!). Fig. 38. Map 40.

Plants epiphytic with rhizophores only at the base of the stems, less often terrestrial with rhizophores borne throughout. Stems very long to long, forming pendent festoons; branches long, remote, intricate or discrete, strongly curled in the dormant state, not fragmenting when dry; or terrestrial stems forming an irregular mat with intricate branches. Upper and under leaves essentially or quite equal in length on the same portion of the stem; leaves long-triangular to ovate-triangular, excluding the adnate base; base glabrous, rarely pubescent, that of the upper leaves adnate to the stem for ¼ to nearly ½ their length; margins eciliate to ascending-ciliate toward the apex; apex of the upper leaves slightly fleshy,

rounded to narrowly carinate, plane to gently beveled in profile; setae not or hardly forming conspicuous tufts at the dry branch-tips, about 1/6 as long as the blade, smooth, greenish, whitish or lutescent, translucent to rarely subopaque. Sporophylls eciliate toward the apex, the broadest about 2 times as broad as the leaves. Megaspores rugose-reticulate with thin rugae on the commissural face, less marked on the outer face, pale yellow.

S. oregana is the only species of the section that is commonly an epiphyte and its long pendent branches are characteristic. Perhaps in relation to the length of the branches, the leaf-base is unusually long and the desiccated branches curl to form ringlets. The last two characters are sufficient for the identification of the occasional plants that grow on soil or rock.

The specimen collected by Scouler (*335*, GH, NY) and frequently cited can not be accepted as coming from Observatory Inlet as stated on the label since this locality is so far north of the otherwise known range.

In megaspore characters *S. oregana* shows a relationship to *S. Underwoodii*, which occasionally has pendent branches although it is not an epiphyte.

Pendent from mossy trunks or branches of trees, particularly *Acer macrophyllum*, or on shaded rocky banks, sea level to 200 m.

Coastal Washington to northern California.

Representative specimens:

UNITED STATES. WASHINGTON: *A. A. & E. G. Heller 4002* (MO, NY, US); *Otis 1399* (GH, NY, US); *Piper 3802* (GH, MO, NY, US); *Suksdorf 6736* (GH, MO, US), *6811* (GH, MO, US); *Thompson 5932* (GH, MO, NY, US), *6241* (GH, MO), *9399* (GH, NY, US), *11425* (GH, MO, NY). OREGON: *E. Hall 694* (F, GH, MO, NY, US); July 12, 1882, *T. Howell* (F, GH, MO, NY, US); Fort [Port] Orford, 1855, *Lieut. A. V. Kautz* (GH, K, US, YU); Oct. 29, 1881, *Pringle* (F, GH, MO, NY, US); *Summers 2209* (YU); *Thompson 4115* (MO, NY, US), *12752* (MO, NY, US). CALIFORNIA: *Eastwood 12185* (F, GH); *T. Howell 696* (GH, US); *H. E. Parks 24274* (F, GH, MO, NY); *H. E. & S. T. Parks 24119* (F, GH, NY, US).

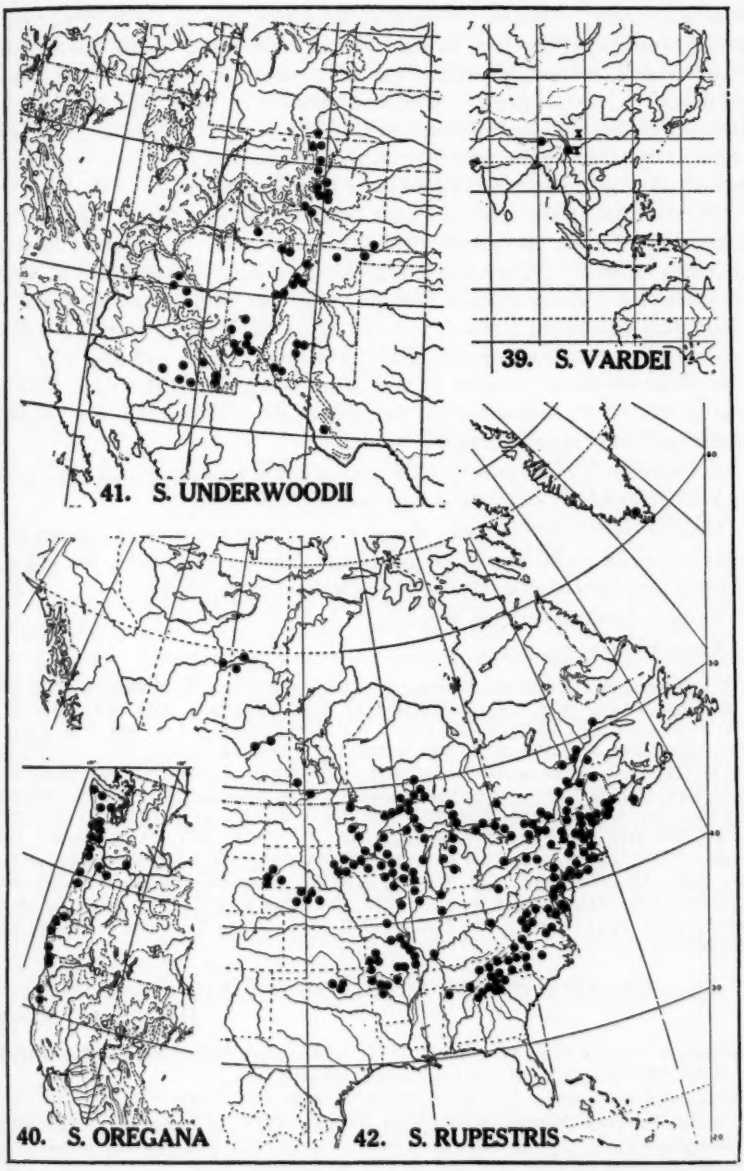
31. SELAGINELLA UNDERWOODII Hieron. in Engl. & Prantl, Nat. Pflanz. 1^4:714. 1901, based on *S. rupestris* var. *Fendleri* Underw. Figs. 39, 40. Map 41.

Selaginella rupestris (L.) Spring var. *Fendleri* Underw. in Bull. Torr. Bot. Club 25:127. 1898. (Lectotype by Weath. in Jour. Arn. Arb. 25:412. 1944: *Fendler 1024* NY!. Paratypes: *Baker 2* NY!; *Wooton* in 1892 NY!).

Selaginella Fendleri (Underw.) Hieron. in Hedwigia 39:303. 1900, not Baker, 1887.

Selaginella Underwoodii var. *dolichotricha* Weath. in Jour. Arn. Arb. 25:412. 1944. (Holotype: *Metcalfe 276* GH! fragment US!. Paratypes: *Ferriss* in 1904 GH!; *Goodding 5* US! fragment GH!; *Maguire et al. 11745* GH!; *Metcalfe 711* US! fragment GH!, *991* GH!).

Stems long or moderately long, forming open, spreading mats, rarely pendent and forming festoons; branches long and remote or moderately so, intricate, not fragmenting when dry. Upper and under leaves equal or subequal in length on the same portion of the stem; leaves subulate to linear to ligulate-long-triangular; base glabrous to pubescent, that of the upper leaves adnate to the stem for about 1/6 their length; margins ciliate, the cilia ascending toward the apex; apex of the


39. S. VARDEI
41. S. UNDERWOODII
40. S. OREGANA
42. S. RUPESTRIS

upper leaves herbaceous to slightly fleshy, slightly rounded to narrowly carinate, plane to abruptly beveled in profile; setae sometimes forming conspicuous tufts at the dry branch-tips, 1/5 as long to nearly as long as the blade, usually smooth, sometimes scabrous, whitish, greenish-white to lutescent, rarely milk-white, usually translucent to rarely opaque. Sporophylls eciliate or with cilia dentiform and ascending toward the apex, the broadest usually 2 to rarely 3 times as broad as the leaves. Megaspores rugose-reticulate on the commissural face, more prominently marked, often with thin rugae, on the outer face, pale orange.

On the basis of the material I have studied I am not able to recognize var. *dolichotricha*. It is a considerably less well-defined entity than others I have recognized as varieties. *S. Underwoodii* from northern Arizona, northern New Mexico and northward is rather uniform in having short and well-differentiated setae and mostly short cilia on the leaves. However, to the south this extreme is also found with the phase that has long and poorly differentiated setae and long cilia. The three characters do not correlate as well as one would like in this area. This is a close parallel to *S. mutica* but in that species the differentiation has proceeded further and varieties are recognized.

S. Underwoodii often grows with *S. mutica* and as mentioned under that species the *S. Underwoodii* in such mixed mats eventually disappears.

Moist or shaded cliffs or rocky slopes, rocky alpine meadows, in crevices or on ledges or among rocks, usually on granitic or other igneous rocks, less often on sandstone or limestone, 800–4000 m., usually from 2000–3000 m.

Texas to Arizona, north to Wyoming.

Representative specimens:

UNITED STATES. WYOMING: *Payson 2503* (US). COLORADO: *C. F. Baker 2* (NY, US); *C. S. Crandall 1054* (NY, US); *Johnston 2424* (GH, US), *2425* (GH, NY, US); *R. M. & A. F. Tryon 5074* (ARIZ, B, BM, CU, F, FI, GH, K, MO, NY, P, PH, RM, UC, US, WS), *5076* (BM, DS, GH, MIN, MO, POM, US), *5078* (B, BM, F, GH, MICH, MO, NY, P, US). NEW MEXICO: *Arsène 15872* (F, MO), *17963* (F, US); 1874, *Fendler 1024* (B, F, GH, MO, NY, US); Mogollon Mountains, Mogollon Creek, Socorro Co., 8000 ft., July 20, 1903, *Metcalfe 276* (GH, MO, NY, US); *Metcalfe 711* (GH, MO, NY, US), *991* (F, GH, MO, NY, US); *Richards & Drouet 363* (F, GH, MO, NY); March 1, 1892, *Wooton* (NY). OKLAHOMA: Aug. 14, 1937, *Wherry* (US). TEXAS: *Ferris & Duncan 3588* (NY, US); *Hinckley 1011* (GH, US), *1156* (US). ARIZONA: *Darrow & Phillips 2781* (GH, MO, US); March, 1904, *Ferriss* (GH); *Goodding 5* (GH, US), *213* (GH, NY); *Maguire et al. 11745* (GH, US); *Phillips 2866* (GH, MO, US); *Pultz & Phillips 2749* (GH,US).

32. SELAGINELLA RUPESTRIS (L.) Spring, in Mart. Fl. Bras. 1^2:118. 1840.

Figs. 41, 42. Map 42.

Lycopodium rupestre L. Sp. Pl. 2:1101. 1753. (Lectotype: *Kalm* LINN!. Kamtchatcha, *Steller* LINN! is excluded as a type; it is *S. sibirica*).

Stachygynandrum rupestre (L.) Beauv. Prod. Aethiog. 110. 1805.

Selaginella Bourgeaui Hieron. in Hedwigia 39:295. 1900, as *Bourgeauii*. (Lectotype: *Bourgeau* on Aug. 15, 1857 B!; Black Hills, *Hayden* MO! is an excellent match. Paratype: *Bourgeau* on Aug. 14, 1857, in part, B! fragment NY!).

Selaginella rupestris f. *Bourgeaui* (Hieron.) Clute, in Fern Bull. 16:52. 1908.

Stems long to rather short, forming open, spreading mats; branches long and remote to moderately short and subapproximate, intricate, rarely only slightly so, not fragmenting when dry. Upper and under leaves equal or subequal, rarely the under slightly longer, on the same portion of the stem; leaves subulate to ligulate-long-triangular; base usually pubescent, rarely glabrous, that of the upper leaves adnate to the stem for ⅕ to ¼ their length; margins ciliate, the cilia spreading toward the apex; apex of the upper leaves herbaceous, rounded, gently to abruptly beveled in profile; setae forming conspicuous tufts at the dry branch-tips, nearly ½ to ¾ as long as the blade, scabrous, usually strongly so, milk-white to tawny, opaque to rarely subopaque. Sporophylls with the cilia piliform and spreading toward the apex, rarely laxly ascending, the broadest about 4 times as broad as the leaves. Megaspores usually 1–2, less often 3 or 4 in a sporangium, rugose to rugose-reticulate, more finely marked on the outer face, bright orange.

S. rupestris is the only species that is certainly apogamous. In the Appalachian mountain region as far north as southern Pennsylvania most of the material has four megaspores in a sporangium and microsporangia are present in the strobilus. Such plants are presumably sexual. In some plants the spore number in the sporangia of a strobilus may vary from 1 to 4. Those having 1–2 megaspores in the sporangia and a few microsporangia are less common. Throughout the rest of the range the most frequent type bears only megasporangia with either 1 or 2 megaspores. This must be an obligate apomict and it is the only kind in a broad band on the northern periphery of the range. From Missouri to Michigan and Vermont there rarely occur specimens that bear strobili having a few microsporangia. The widespread apogamy may explain the uniformity of *S. rupestris* over its broad range. All other wide-ranging species are much more variable. The occasional occurrence of 1–2 megaspores in sporangia of *S. densa* and *S. sibirica* may also indicate apogamy.

S. rupestris most closely resembles *S. densa* var. *densa* and it can best be separated by its radially symmetrical leafy stem. In addition, in the area in Canada where the two grow together, all of the *S. rupestris* have one or two megaspores in a sporangium while *S. densa* has, with rare exception, four. When *S. rupestris* grows in nearly pure sand and other vegetation is sparse it will form circular, or in age, ring-shaped mats.

Exposed or less often shaded cliffs, rocky bluffs, of acidic igneous or sedimentary rocks, gravel or sandy soil, up to 1900 m.

Central and eastern United States to northeastern Alberta, Quebec and Greenland.

Representative specimens:

GREENLAND: July 13, 1946, *T. W. Böcher* (GH).

CANADA. NOVA SCOTIA: *Fernald & Long 23098* (GH, US). QUEBEC: *Victorin 8421* (MO, US); *Victorin et al. 4201* (MO, US). ONTARIO: *C. E. & G. K. Jennings 7362* (GH, US), *7389* (GH, US); July 20, 1899, *Umbach* (MIN, NY, US); *Van Eseltine 501* (GH, US). MANITOBA: Fort Ellice, Aug. 15, 1857, *Bourgeau* (B), Aug. 14, 1857 (B, NY); *Macoun 137* (BM); *Macoun & Herriot 70372* (B, F, GH, NY). SASKATCHEWAN:

Raup 6305 (GH, NY), *6929* (GH, NY). ALBERTA: *Raup & Abbe 4451* (GH, NY), *4608* (GH, NY).

UNITED STATES. MAINE: *Hodgdon* (Pl. Exsicc. Gray. 611) (F, GH, MO, NY, US). VERMONT: Sept. 11, 1920, *Dutton* (F, GH, MO); *Eggleston 2199* (GH, NY, US). CONNECTICUT: 1859, *D. C. Eaton* (F, GH, MO). NEW YORK: *Robinson & Maxon 15* (GH, NY, US), *32* (F, GH, MO, NY, US). PENNSYLVANIA: *Heller & Halbach 706* (GH, MO, US). VIRGINIA: *Steele & Steele 166* (GH, MO, NY, US). NORTH CAROLINA: *Biltmore Herb. 3432a* (NY, US). SOUTH CAROLINA: *Mackenzie 2997* (MO, US); *Clausen & Trapido 3663* (NY, US). GEORGIA: *Beyrich 198* (US); *Correll 6615* (GH, MO, US); *Harper 215* (GH, MO, NY). ALABAMA: *Harper 3403* (F, MO). MICHIGAN: *R. W. Chaney 181* (F, GH, US); *R. M. & P. F. Tryon 4695* (GH, MO). INDIANA: June 16, 1900, *Umbach* (GH, US). TENNESSEE: *Gattinger* (Curtiss, N. Am. Pl. 3796) (F, GH, MO, NY, US). WISCONSIN: *R. M. & A. F. Tryon 5005* (B, BM, GH, K, MO, P, US). ILLINOIS: *A. Chase 1584* (F, US); *Evers 32650* (MO). MINNESOTA: *Bergman 3156* (GH, NY, US); *Moyle 483* (F, GH, MO, US). MISSOURI: *Bush 4744* (GH, MO, NY, US), *5210* (GH, NY, US). ARKANSAS: *E. J. Palmer 35561* (F, GH, MO, NY). SOUTH DAKOTA: *Murdoch 4304* (F, GH, US). NEBRASKA: *Kiener 11323* (US), *23695* (MO). KANSAS: 1886, *E. N. Plank 14* (GH). OKLAHOMA: *Bush 835* (GH, MO, NY).

33. SELAGINELLA DENSA Rydb. in Mem. N. Y. Bot. Gard. 1:7. Feb. 15, 1900. (Holotype: *Havard* NY! marked as type by Rydb., fragment US!. Paratypes: *Newberry* NY!; *Williams 534; Tweedy 172;* Missoula, Mont. 1898, *Williams & Griffith;* Silver Bow Co., Mont., *Mrs. Jennie Moore;* the last four collections probably at MONT. *Watson* in 1880 GH! is excluded as type material; it is S. *Wallacei*). Map 43.

Stems short, forming flat cushion mats; branches short, approximate, discrete, not fragmenting when dry. Under leaves definitely longer than the upper on the same portion of the stem, or sometimes equal to the upper on the assurgent branch-tips; leaves ligulate to ligulate-lanceolate to ligulate-long-triangular; base glabrous to pubescent, that of the upper leaves adnate to the stem for ⅕ to ¼ their length; margins eciliate or with the cilia ascending to spreading toward the apex; apex of the upper leaves herbaceous to fleshy, slightly to broadly rounded, plane to truncate in profile; setae forming conspicuous tufts at the dry branch-tips, ¼ to ¾ as long as the blade, smooth to scabrous, milk-white and opaque to tawny or whitish and subopaque to lutescent and translucent. Sporophylls eciliate or with the cilia dentiform to piliform and ascending, rarely laxly ascending, toward the apex, the broadest 3 to 4 times as broad as the leaves; seta base often strongly broadened and flattened. Megaspores prominently and coarsely rugose-reticulate to slightly rugose, most prominently marked in the equatorial region, pale to bright orange.

S. densa is one of the most complex species of the section. The morphological extremes of the three varieties are amply distinct, but from Montana south to Colorado all occur and with an increasing number of intermediates. In Colorado nearly all possible intermediate conditions between the three may be found and over a third of the collections I have seen from there are such intermediates. To the south, in the mountains of Arizona, New Mexico and Texas, there is less variation. Var. *Standleyi* and var. *densa* are lacking and there are no intermediates with var. *Standleyi*. The material there is either typical var. *scopulorum* or intermediates of it varying toward var. *densa*.

It is not possible to withhold recognition from the three extremes since they do have distinctive characters and distribution in the northern part of the range of the species. At the same time, it must be admitted that identification, particularly of the material from Colorado, is sometimes rather arbitrary. The intermediates show all transitions between the two extremes in respect to the varietal characters. Some specimens will be intermediate in one character, others in two or three. Some will have some of the leaves and sporophylls intermediate, others typical of one variety; or some leaves and sporophylls will be typical of one variety, others of them typical of another variety.

The intermediate specimens have, for the purposes of discussion, been divided into two kinds. Those that are more or less halfway between the typical state of two varieties are called intermediate. Those that depart from the typical state of a variety to a lesser degree are mentioned as specimens showing a tendency toward another variety. Such specimens can be identified with one variety quite satisfactorily but are not entirely typical of it.

Of the three varieties, var. *densa* most closely resembles S. *rupestris* and the differences are discussed under that species. Rarely S. *densa* may have some megasporangia with two megaspores but this has not been found with sufficient regularity within a strobilus to indicate functional apogamy as in S. *rupestris*.

Southwestern Manitoba to southern Alaska, south to Texas, Arizona and northern California.

KEY TO VARIETIES

a. Apices of the leaves and sporophylls plane to abruptly beveled in profile; setae of the leaves white or whitish, or lutescent only at the base, opaque to subopaque. b.
  b. Sporophylls eciliate toward the apex ..... 33a. var. *scopulorum*, p. 67
  b. Sporophylls dentiform to piliform-ciliate to the apex ..... 33b. var. *densa*, p. 68
a. Apices of the leaves and sporophylls predominantly or all truncate in profile; setae of the leaves whitish- to greenish- to entirely [illegible], translucent ..... 33c. var. *Standleyi*, p. 71

33a. SELAGINELLA DENSA var. **scopulorum** (Maxon) Tryon, comb. nov.

Fig. 43. Map 44.

Lycopodium bryoides Nutt. ex Baker, Handb. Fern Allies, 35. 1887, in synon. Placed here on the basis of the specimen so labeled at Kew! (fragment NY!) which agrees with Baker's description.

Selaginella scopulorum Maxon, in Amer. Fern Jour. 11:36. 1921. (Holotype: *Standley 15732* US!. Paratypes: *Ferris & Duthie 941* US!; *Flett 3092* US!; *Goodding 483* US!; *Heacock 235* US!; *Mearns 4274* US!; *Merrill & Wilcox 1218* US!; *Shaw 398* US!, *902* US!, *1060* US!; *Standley 15318a* US!, *15598* US!, *16216* US!, *16255* US!, *16288* US!, *16378* US!, *17055* US!, *17164a* US!, *17979* US!, *18050* US!, *18185* US!; *Suksdorf 8834* US!; *Ulke* on Aug. 25, 1917 US!; *Umbach 856* US!).

Selaginella columbiana A. A. Eaton ex Maxon, in Amer. Fern Jour. 11:37. 1921, in synon. (Evidently based on *Shaw 398* and *Heacock 235*).

Apex of leaves plane to abruptly beveled in profile; setae white, or lutescent only at the base, opaque, rarely subtranslucent. Sporophylls eciliate toward the apex; apex plane to gently beveled in profile.

Var. *scopulorum* is apparently the least specialized of the varieties of S. *densa*. Intermediates with var. *densa* in the central and southern Rocky Mountains are frequent but intermediates with var. *Standleyi* are rare.

The following are examples of intermediates between var. *scopulorum* and var. *densa*. New Mexico, *Arsène & Benedict 16370* (US); Arizona, *Phillips & Reynolds 2900* (GH); Colorado, *Underwood & Selby 133* (NY); Utah, *Hermann 5063* (MO).

Examples of specimens of var. *scopulorum* with a tendency toward var. *densa* are: Colorado, *Knowlton 82* (US), *McKelvey 4695* (GH); Utah, *Harrison & Larsen 7891* (MO); Arizona, *Phillips & Reynolds 2900* (US).

Colorado, *Rydberg & Vreeland 6588* (NY) represents var. *scopulorum* with a tendency toward var. *Standleyi*.

Intermediates between var. *scopulorum* and var. *Standleyi* are mentioned under that variety while specimens of var. *densa* with a tendency toward var. *scopulorum* are mentioned under var. *densa*.

Usually in rocky alpine tundra, also cliffs, talus slopes, on ledges, among boulders or in thin soil over rocks, on igneous or sedimentary rocks, 700–4660 m.

Alberta to British Columbia, south to Texas, Arizona and northern California.

Representative specimens:

CANADA. ALBERTA: *Scamman 2790* (GH); *Rosendahl 1074* (US). BRITISH COLUMBIA: *Heacock 235* (BM, GH, MO, NY, US); *Hitchcock & Martin 7435* (GH, MO, NY); *Shaw 398* (BM, GH, MO, NY, US), *902* (BM, GH, NY, US), *1060* (BM, GH, MO, NY, US).

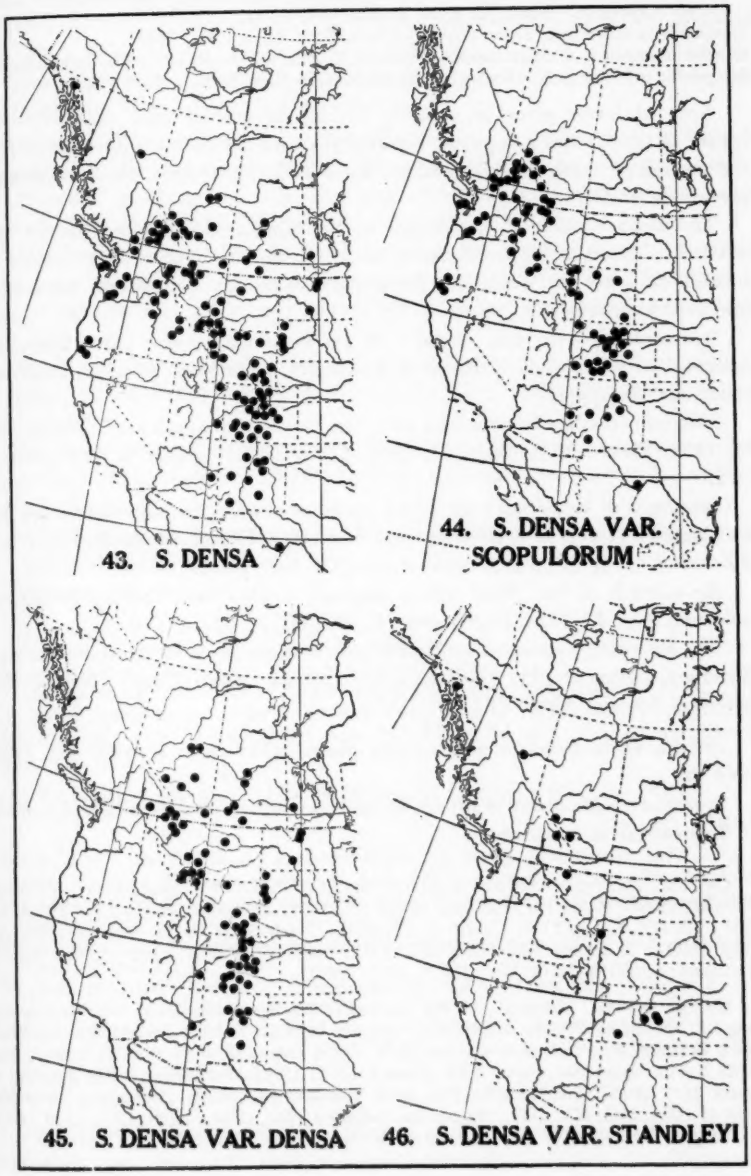
UNITED STATES. MONTANA: *Standley 15318a* (US), *15598* (US), vicinity of Cracker Lake, Glacier National Park, 1740–1920 m., July 15, 1919, *Standley 15732* (US), *Standley 16216* (US), *16255* (US), *16288* (US), *16378* (US), *17055* (US), *17164a* (US), *17979* (US), *18050* (US), *18185* (US); Aug. 25, 1917, *Ulke* (US); *Umbach 856* (F, MIN, NY, US). WYOMING: *Goodding 483* (F, GH, MO, NY, US); *Mearns 4274* (US); *Merrill & Wilcox 1218* (GH, NY, US). COLORADO: *Cox 290* (F, MO); *Murdoch 4787* (F, US). UTAH: *E. B. & L. B. Payson 4037* (GH, MO). TEXAS: *Moore & Steyermark 3245* (US). NEW MEXICO: *Metcalfe 1172* (BM, F, GH, MIN, MO, NY, US). ARIZONA: 1913, *Ferriss* (US). IDAHO: *Epling 7033* (F, MO, US). WASHINGTON: *Flett 3092* (US); *Suksdorf 8834* (GH, MO, NY, US). OREGON: *Ferris & Duthie 941* (US); *Maguire & Holmgren 27132* (GH, NY, US). CALIFORNIA: *J. T. Howell 13521* (US); *L. C. Wheeler 3036* (US).

33b. SELAGINELLA DENSA var. **densa**. Figs. 44, 45, 47. Map 45.

Selaginella longipila Hieron. in Hedwigia 39:291. Dec. 28, 1900. (Lectotype: *Bourgeau* in 1858 (Herb. Kew Exsicc. no. 1239, wrongly labeled "Himalaya") B! Paratype: *"Herb. Griffith,* Bhotan" B! fragment NY!, collector and locality unknown).

Selaginella rupestris (L.) Spring f. *longipila* A. Br. ex Hieron. in Hedwigia 39:291. 1900, in synon.

Selaginella Engelmannii Hieron. in Hedwigia 39:294. Dec. 28, 1900. (Holotype: *Engelmann* B!).


43. S. DENSA
44. S. DENSA VAR. SCOPULORUM
45. S. DENSA VAR. DENSA
46. S. DENSA VAR. STANDLEYI

Selaginella Haydenii Hieron. in Hedwigia 39:296. Dec. 28, 1900, as *Haydeni*. (Lectotype: *Hayden* Bl. Paratype: *Lyall* B! fragment NY!).
Selaginella rupestris var. *densa* (Rydb.) Clute, Fern Allies, 142. 1905.
Selaginella rupestris f. *Engelmannii* (Hieron.) Clute, in Fern Bull. 16:52. 1908.
Selaginella rupestris f. *Haydenii* (Hieron.) Clute, in Fern Bull. 16:52. 1908.

Apex of leaves plane to abruptly beveled in profile; setae milk-white and opaque to whitish and subopaque. Sporophylls with the cilia dentiform to piliform and ascending, rarely laxly ascending, toward the apex; apex plane to abruptly beveled in profile.

The misapplication of *S. longipila* to the Himalayan *S. indica*, because of a mixture of labels has been discussed under *S. indica*. The type specimens are actually *S. densa* var. *densa* but fortunately Rydberg's well-known name has a few months priority.

Intermediates with var. *scopulorum* are mentioned under that variety and specimens of var. *Standleyi* that show a tendency toward var. *densa* are mentioned under var. *Standleyi*.

Specimens that are intermediate with var. *Standleyi* are such as: Colorado, Aug. 26, 1896, *Holm* (MO), Sept. 12, 1905, *S. Shaw* (GH), July 6, 1937, *Wherry* (US).

Specimens of var. *densa* that show a tendency toward var. *scopulorum* are such as: Colorado, *F. E. & E. S. Clements 532* (GH,MO,NY,US); New Mexico, *Arsène & Benedict 15877* (F, US), *Fendler 1025* (BM, GH, MO).

An example of var. *densa* with a tendency toward var. *Standleyi* is: Empire, Colorado, Aug. 27, 1874, *Engelmann* (B, MO, US).

The following specimens are rather intermediate between all three varieties: Wyoming, *Hermann 4665* (MO); Colorado, *Ewan 12699* (Ewan); New Mexico, *Arsène & Benedict 18056* (F).

Prairies, alpine meadows or dry rocky places, acidic rocks or sandy soil, 1100–4000 m.

Southeastern Manitoba to British Columbia, south to New Mexico and Arizona.

Representative specimens:

CANADA. MANITOBA: *Macoun & Herriot 70373* (F, GH, NY). SASKATCHEWAN: *Boivin & Gillett 8686* (MO); Fort Carlton, March 29, 1858, *Bourgeau* (Herb. Kew Exsicc. no. 1239) (B, NY, P, US, YU); *Cowles 43* (F, MO); *Gillett 6022* (MO). ALBERTA: *Breitung 5553* (MO); *S. Brown 128* (GH, MO, US); *Malte & Watson 1229* (GH). BRITISH COLUMBIA: *Calder & Savile 7677* (MO), *9221* (MO).

UNITED STATES. "Oregon", 49 N. Lat., 1858–59, *Lyall* (B, NY). NORTH DAKOTA: Aug. 12, 1908, *Lunell* (GH, MIN, US), Sept. 10, 1908 (NY, US). SOUTH DAKOTA: Black Hills, 1853–54, *F. V. Hayden* (B, MO, NY, US); *Hayward 315* (F, NY). MONTANA: Little Rocky Mountains, Sept. 1889, *Havard* (NY, US); *Newberry* (NY); *Rydberg & Bessey 3517* (F, GH, MIN, NY, US); *R. S. Williams 534* (US). WYOMING: *A. Nelson 8781* (F, GH, MO, NY, US). COLORADO: *Johnston 3896* (US), *3897* (US), *3898* (US); *Rydberg & Vreeland 6590* (NY); *L. & R. Williams 2126* (GH, MO).

33c. SELAGINELLA DENSA var. **Standleyi** (Maxon) Tryon, comb. nov.

Fig. 46. Map 46.

Selaginella Standleyi Maxon, in Smiths. Misc. Coll. 72[5]:9. 1920. (Holotype: *Standley 17228* US!. Paratypes: *Brown 95* US!; *Standley 15363* US, *16970* US!, *17483* US!, *18136* US!; *Ulke* on Aug. 25, 1917 US!).

Apex of leaves predominantly or entirely truncate in profile; setae whitish- to greenish-lutescent to lutescent, translucent. Sporophylls eciliate or with the cilia dentiform or piliform and ascending toward the apex; apex truncate, rarely abruptly beveled in profile.

Intermediates of var. *Standleyi* and var. *densa* and material of var. *densa* with a tendency toward var. *Standleyi* are mentioned under var. *densa*. Specimens of var. *scopulorum* with a tendency toward var. *Standleyi* are mentioned under var. *scopulorum*.

Specimens of var. *Standleyi* with a tendency toward var. *densa* are such as: Montana, *Standley 16970* (US), *Van Schaack 2786½* (MO); Colorado, *Johnston 3899* (GH).

Specimens intermediate between var. *Standleyi* and var. *scopulorum* are: Montana, Aug. 11, 1931, *J. H. Schaffner* (BM); Colorado, *Underwood & Selby 133* (NY), *Vasey* (MO).

Rocky alpine meadows, dry rocky slopes and cliffs, acidic rocks, 1500–4660 m. Southern Alaska to Colorado.

Representative specimens:

ALASKA: *A. & A. Krause 162* (B).

CANADA. ALBERTA: S. *Brown 95* (GH, MO, US). BRITISH COLUMBIA: Aug. 30, 1904, *Holway & Butters* (MIN, US); *Raup & Abbe* (GH, NY).

UNITED STATES. MONTANA: *Barkley 1725* (GH, MO, US); *Standley 15363* (US), vicinity of Sexton Glacier, Glacier National Park, Aug. 7, 1919, *Standley 17228* (US), *Standley 17483* (US), *18136* (US); Aug. 25, 1917, *Ulke* (US). COLORADO: *Johnston 3903* (NY, US).

34. SELAGINELLA SIBIRICA (Milde) Hieron. in Hedwigia 39:290. 1900.

Fig. 48. Map 47.

Selaginella rupestris (L.) Spring f. *sibirica* Milde, Fil. Europ. Atlant. 262. 1867. (Lectotype: Unalaska, *Chamisso*. Paratypes: Ajan, *Tilling;* Dahuria ad flumen Ingoda, *Pallas*).

Selaginella rupestris f. *amurensis* Milde, Fil. Europ. Atlant. 262. 1867. (Holotype: Amur, *Maximowicz*).

Selaginella rupestris f. *manchuriensis* Milde, Fil. Europ. Atlant. 262. 1867. (Holotype: Khalkyli, *Maack*).

Selaginella Schmidtii Hieron. in Hedwigia 39:292. 1900. (Lectotype: *Schmidt* B! fragment NY!. Paratype: *Chamisso* B! fragment NY!).

Selaginella Schmidtii var. *Krauseorum* Hieron. in Hedwigia 39:293. 1900. (Lectotype: *A. & A. Krause 53* B! fragment NY!. *A. & A. Krause 162* B! is excluded as a type; it is S. *densa* var. *Standleyi*).

Selaginella rupestris f. *Schmidtii* (Hieron.) Clute, in Fern Bull. 16:52. 1908.

Stems long to moderately long, forming open, spreading mats; branches long and remote to moderately short and subapproximate, intricate, not fragmenting when dry. Upper and under leaves equal or subequal in length, or the under

slightly longer, on the same portion of the stem; leaves linear to ligulate-long-triangular; base usually glabrous, less often pubescent, that of the upper leaves adnate to the stem for 1/6 their length; margins ciliate, the cilia spreading to laxly ascending toward the apex; apex of the upper leaves fleshy, broadly rounded to carinate, subtruncate to usually truncate in profile; setae forming conspicuous tufts at the dry branch-tips, 1/3 to 3/5 as long as the blade, scabrous, milk-white to white to tawny, opaque to translucent. Sporophylls eciliate or with the cilia piliform to dentiform and ascending toward the apex, the broadest 3 to usually 4 times as broad as the leaves; seta base usually strongly broadened and flattened. Megaspores rugose to rugose-reticulate, pale yellow to pale orange.

The Alaskan and Yukon material is relatively uniform while that from Asia is less so. In addition to the typical form with short, milk-white setae a phase occurs in Asia with longer and tawny setae, and also occasional specimens bear strobili having 1 to 2 megaspores in a sporangium. This is quite parallel with S. *densa* var. *densa*, the reduced number of megaspores being so rare that it is not possible to be certain of apogamy.

S. *sibirica* is most similar to S. *densa* var. *Standleyi* from which it may be separated by the white to tawny rather than lutescent setae and the intricate rather than discrete branches. It is separated from S. *shakotanensis*, which also grows in Japan, by the leaf-bases that place the two in different series. The seta length likewise distinguishes these species—in S. *sibirica* they are 1/3–3/5 as long as the blade while in S. *shakotanensis* they are 1/5 as long.

The only sporelings observed in this study were seen in the soil of a mat of S. *sibirica* collected by Calder & Billard (*2995* MO). These are discussed in some detail in the introduction.

Dry, rocky, open places or on cliffs, 130–2400 m.

Yukon and Alaska to Trans Baikal, Manchuria and Japan.

Representative specimens:

CANADA. YUKON: *Calder & Billard 2995* (MO), *4454* (MO), *4601* (MO, US); *Tarleton 188* (NY, US).

ALASKA: UNALASKA, *Chamisso* (B, NY); *Flett 1529* (NY, US); *A. E. & R. T. Porsild 690* (GH, MO, US); *Scamman 1981* (GH, MO).

BEHRING STRAITS: Emma Harbour, Sept. 21, 1881, *A. & A. Krause 53* (B, NY); *C. Wright* (GH, NY, US, YU).

UNION OF SOVIET SOCIALIST REPUBLICS. KAMTCHATKA: *Eyerdam* (F); *Novogablenov 541* (US). SACHALIN: *Fr. Schmidt* (B, GH, NY, US). TRANS BAIKAL: Ingoda river (Dahuria), *Fischer* (GH, P).

JAPAN: *Faurie 1100* (P), *7279* (P), *8496* (MO, P), *9687* (MO, P), *13903* (P).

35. SELAGINELLA WATSONII Underw. in Bull. Torr. Bot. Club 25:127. 1898, as *Watsoni*. (Holotype: *Watson* in 1869 NY!. Paratypes: *Watson* in 1868 NY!; *Hansen 879* NY!; *Coville & Funston 2071* NY!; *Brewer 2103* NY!).

Figs. 49–51. Map 48.

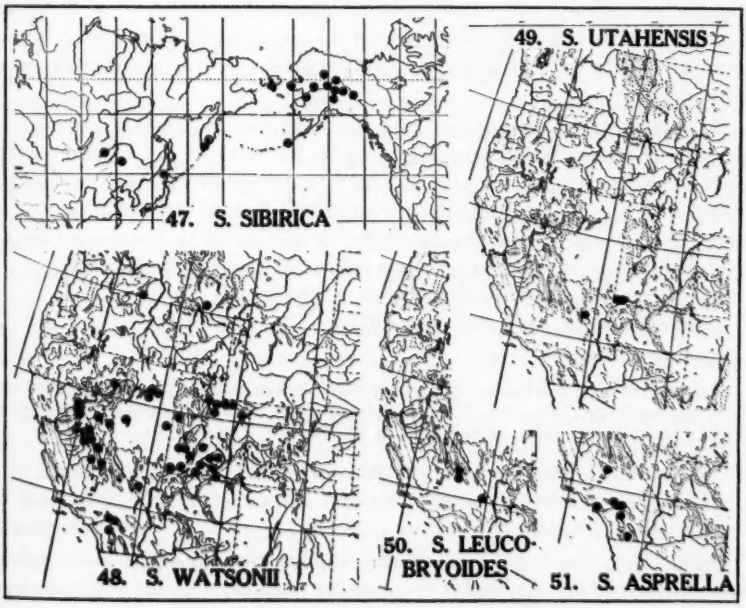
Stems short to moderately long, forming rounded cushion mats; branches short, subapproximate to moderately long and remote, intricate, not readily fragmenting when dry but rather easily broken by hand. Upper and under leaves equal in

length, or the under slightly longer, on the same portion of the stem; leaves ligulate to broadly ligulate to ligulate-long-triangular; base glabrous to slightly pubescent, that of the upper leaves adnate to the stem for 1/5 to 1/3 their length; margins eciliate, rarely with ascending cilia toward the apex; apex of the upper leaves fleshy, narrowly to broadly carinate, subtruncate to truncate in profile; setae not or hardly forming conspicuous tufts at the dry branch-tips, 1/5 to 1/4, rarely 1/3, as long as the blade, usually smooth, sometimes slightly scabrous, greenish-white to greenish-lutescent to whitish-lutescent, translucent to subopaque. Sporophylls eciliate toward the apex, the broadest about 2 times as broad as the leaves. Megaspores rugose to rugose-reticulate, pale orange.

S. Watsonii is characterized by its fleshy leaves which are usually eciliate and short-setate. In habit it forms dense rounded mats with intricate branches. The fragile nature of the stem of the next three species is poorly developed in *S. Watsonii*. The stems can be easily broken by hand but specimens do not fragment in packets or with ordinary handling. It seems probable that the next three species have been derived from *S. Watsonii* or a common ancestor.

Exposed or shaded cliffs, talus slopes or rocky alpine meadows, in crevices or on boulders or among rocks, usually related to igneous rocks, rarely to limestone, 1800–4300 m., usually 3000–3700 m.

Southwestern Montana to northeastern Oregon, south to Utah and southern California.



Representative specimens:

UNITED STATES. MONTANA: *T. D. Howe 66* (US). UTAH: *G. J. Goodman* (GH, MO, NY, US); *M. E. Jones 1246* (NY, US); *Maguire & Richards 13166* (GH, MO); *E. B. & L. B. Payson 4917* (GH, MO, US), *5074* (GH, MO, NY, US); *Rydberg & Carlton 6566* (GH, NY, US); Cottonwood Cañon, 9500 ft., July, 1869, *S. Watson 1370* (NY, YU). NEVADA: *Heller 11054* (F, GH, MO, NY, US); *Maguire 21090* (GH, NY, US); Sept., 1868, *S. Watson 1370* (NY, US). OREGON: July 1, 1931, *Wherry* (US). CALIFORNIA: *Brewer 2103* (NY, YU); *Coville & Funston 2071* (NY, US); Sept. 5, 1923, *C. C. Hall* (F, MO, NY, US); *Hansen 879* (BM, MO, NY, US); *Heller 7167* (GH, MO, NY, US); *R. M. & A. F. Tryon 5060* (ARIZ, B, BM, CU, DS, F, FI, GH, K, MICH, MIN, MO, NY, P, PH, POM, RM, UC, US, WS).

36. SELAGINELLA UTAHENSIS Flowers, in Amer. Fern Jour. 39:83. 1949. (Holotype: *Cottam 5644* UT fragment US!. Paratype: *Cottam 8817* UT).

Fig. 52. Map 49.

Stems moderately short, forming rounded to flat cushion mats; branches moderately short to moderately long, approximate to nearly remote, intricate, readily fragmenting when dry. Upper and under leaves equal or subequal in length on the same portion of the stem; leaves subulate to ligulate-lanceolate to ligulate-long-triangular; base usually glabrous, sometimes pubescent, that of the upper leaves adnate to the stem for ¼ their length; margins eciliate to ascending-ciliate toward the apex; apex of the upper leaves slightly fleshy, broadly carinate, gently to rather abruptly beveled in profile; setae not forming conspicuous tufts at the dry branch-tips, less than ⅕ as long as the blade to essentially absent, smooth, whitish to greenish- to lutescent-whitish, subopaque. Sporophylls eciliate or with the cilia dentiform and strongly ascending toward the apex, the broadest 2 to 3 times as broad as the leaves. Megaspores slightly rugose-reticulate to slightly rugose, yellow-orange.

S. utahensis may be separated from the next two species, that also share the character of readily fragmenting stems, by its leaves which are muticous or have short, smooth setae. The anatomical basis of the fragmenting stems has not been investigated. In mounted material the parts will be held together if glue or soil holds the roots and rhizophores firmly but in packets or in unmounted material ordinary handling of the sheet will soon reduce the stems to small pieces.

Ledges and crevices of sandstone cliffs, 1500–2300 m

Southern Nevada and southwestern Utah.

Specimens examined:

UNITED STATES. UTAH: Lady Mountain, Zion National Park, 6,500 ft., April 5, 1931, *W. P. Cottam 5644* (MO, US); *Degener & Peiler 16982* (NY); *Eastwood & Howell 1159* (US); *Flowers 3249* (MO). NEVADA: June 28, 1930, *E. Jaeger* (US).

37. SELAGINELLA LEUCOBRYOIDES Maxon, in Smiths. Misc. Coll. 72[5]:8. 1920. (Holotype: *Munz & Harwood 3789* US!. Paratypes: *Coville & Funston 628* US!; *Munz, Johnston & Harwood 4226* US!). Fig. 53. Map 50.

Stems short, forming flat or rounded cushion mats; branches short, approximate, intricate or discrete, readily fragmenting when dry. Upper and under leaves

equal in length, or the under slightly longer, on the same portion of the stem; leaves linear to ligulate-ovate; base glabrous to pubescent, that of the upper leaves adnate to the stem for ¼ or less their length; margins eciliate to ascending-ciliate toward the apex; apex of the upper leaves herbaceous, slightly to broadly rounded, gently to abruptly beveled in profile; setae not forming conspicuous tufts at the dry branch-tips, ⅕ or less as long as the blade, scabrous to slightly scabrous, milk-white and opaque, rarely white and translucent. Sporophylls eciliate or with the cilia dentiform and ascending toward the apex, the broadest about 3 times as broad as the leaves. Megaspores slightly rugose to rugose-reticulate, to nearly smooth on the outer face, pale orange.

The short, white, scabrous and usually opaque setae are characteristic of S. *leucobryoides*. It shares the peculiar character of fragile stems with S. *utahensis* and S. *asprella*.

Rocky slopes, in crevices or among rocks, 900–2300 m.

Southeastern California.

Specimens examined:

UNITED STATES. CALIFORNIA: *Coville & Funston 628* (NY, US); *Coville & Gilman III* (US); *J. T. Howell 3989* (F, GH, MO, US); Bonanza Mine, Providence Mountains, 2800 ft., March 30, 1920, *P. A. Munz & R. D. Harwood 3789* (F, GH, NY, US); *Munz, Johnston & Harwood 4226* (US).

38. SELAGINELLA ASPRELLA Maxon, in Smiths. Misc. Coll. 72[5]:6. 1920. (Holotype: *Johnston 1815* US!. Paratypes: *Johnston 1595* US!, *1807* US!).

Fig. 54. Map 51.

Stems short to moderately short, forming rounded or flat cushion mats; branches moderately short and remote to short and subapproximate, intricate, rather readily fragmenting when dry. Upper and under leaves essentially equal in length on the same portion of the stem; leaves linear-lanceolate to lanceolate-ovate to lanceolate-long-triangular; base pubescent, rarely glabrous, that of the upper leaves adnate to the stem for about ⅓ their length; margins eciliate to ascending-ciliate toward the apex; apex of the upper leaves herbaceous, broadly rounded to carinate, nearly plane to truncate in profile; setae forming conspicuous tufts at the dry branch-tips, ⅓ to over ½ as long as the blade, scabrous, white and translucent to rarely milk-white and opaque. Sporophylls eciliate or with the cilia piliform to dentiform and strongly ascending toward the apex, the broadest about 3 times as broad as the leaves. Megaspores prominently and coarsely rugose-reticulate, most prominently marked in the equatorial region, pale yellow to pale orange.

S. *asprella* is characterized by its long, scabrous, white, usually translucent setae. Of the three species with readily fragmenting stems, it is the furthest removed from the presumed ancestor, S. *Watsonii*.

Open areas in rocky soil or in crevices at the base of boulders, igneous rock, 1800–2700 m.

Southern California.

Specimens examined:

United States. California: *J. T. Howell 5031* (US); *Jaeger 276* (US); *I. M. Johnston 1595* (MO, US), *1807* (MO, US), West end of Ontario Peak, San Antonio Mountains, 6000 ft., March 25, 1918, *I. M. Johnston 1815* (MO, US); *Munz 7612* (NY), *9683* (US), *17165* (GH); Sept. 14, 1921, *Saunders* (US); April, 1906, *Streeter* (NY, US); *R. M. & A. F. Tryon 5059* (ARIZ, B, BM, CU, DS, F, FI, GH, K, MICH, MIN, MO, NY, P, PH, POM, RM, UC, US, WS).

Series **Eremophilae** Tryon, ser. nov.

Rhizomata et stolones et gemmae nulla. Caules prostrati. Apices ramorum involuti statu inerte. Caules frondosi valde dorsiventrales. Folia supera base abrupte adnata caule distincta colore, folia infera base valde decurrente. Typus: *Selaginella eremophila* Maxon.

Plants terrestrial; rhizomes, stolons and basal buds absent. Stems prostrate or assurgent at the branch tips, with rhizophores produced generally throughout; stems long to rather short, forming open or usually rather compact, rounded or usually flat mats. Branches moderately long to short, remote to subapproximate, usually intricate, branch tips involute in the dormant state. Leafy stems strongly dorsiventral, the under leaves appressed, the upper erect, the under longer, usually thinner and different in shape from the upper; zone of green leaves much longer on the upper side of the stem, very short to absent on the under side. Upper leaves with the base abruptly adnate, distinct from the stem in color, under leaves with the base very strongly decurrent.

The species of *Eremophilae* form a homogeneous series and one in which there is increasing specialization in the dorsiventral habit. S. *peruviana* is strongly dorsiventral in position, length and shape of the upper and under leaves; in S. *arizonica* they are also different in texture. In S. *eremophila* the setae are highly specialized and the leaves of S. *Parishii* are muticous. Finally, in S. *Landii*, the under leaves are unusually long in relation to the upper and they are setate while the upper leaves are muticous. The species are all quite distinct with the exception of the first two, S. *peruviana* and S. *arizonica*, which are rather closely related.

KEY TO SPECIES

a. All leaves setate (sometimes only in the bud); under leaves less than twice as long as the upper. b.

b. Setae mostly or entirely persistent, stout, straight. c.

c. Under leaves subulate, acuminate, broadest at or very near the base, rarely linear-lanceolate, not appreciably thinner than the herbaceous upper leaves, setae 0.5–1.0 mm. long. Oklahoma to New Mexico; Mexico; Peru to Argentina ..... 39. S. *peruviana*, p. 77

c. Under leaves lanceolate to lanceolate-ovate, broadest above the base, papyraceous, the upper fleshy, setae 0.1–0.3 mm. long. Texas to Arizona; Baja California ..... 40. S. *arizonica*, p. 78

b. Setae mostly early-deciduous (sometimes present only in the bud), delicate, filiform, tortuous ..... 41. S. *eremophila*, p. 80

a. Upper leaves, or all leaves muticous. d.

d. All leaves muticous; under leaves about twice, or less, as long as the upper; upper leaves lanceolate to lanceolate-triangular....42. *S. Parishii*, p. 80

d. Upper leaves muticous; under leaves predominantly short-setate, the setae persistent; under leaves over twice as long as the upper; upper leaves long-deltoid or with parallel sides toward the base....43. *S. Landii*, p. 81

39. SELAGINELLA PERUVIANA (Milde) Hieron. in Hedwigia 39:307. 1900.

Figs. 55, 56. Map 52.

Lycopodium ciliatum Ruiz ex Spring, in Nouv. Mém. Acad. Roy. Belg. 24 (Monog. Fam. Lycopod.):55. 1850, in synon. (evidently based on *Ruiz 98* B!).

Selaginella rupestris (L.) Spring f. *peruviana* Milde, Fil. Europ. Atlant. 263. 1867. (Holotype: *Ruiz 98* B!; the lower right-hand specimen of *Wilkes Exped. 1*, Peru, GH! is identical).

Selaginella rupestris var. *mexicana* Milde, Fil. Europ. Atlant. 263. 1867. (*Aschenborn 65* B! is so annotated by Milde or A. Br.).

Selaginella rupestris var. *peruviana* (Milde) Hieron. in Engl. Bot. Jahrb. 22:417. 1896.

Selaginella Aschenbornii Hieron. in Hedwigia 39:305. 1900. (Lectotype: *Aschenborn 65* B!; *Palmer 554* GH! and US! (62778) is identical. Paratypes: *Schaffner 10* B!; *Schaffner* vel *Sartorius* B; *Hahn* in 1868 B; Mexico City, *Schmitz* B; Toluta, *von Chrismar* B. Vancouver Island, *J. H. Henry* B should be excluded as a type; it is probably *S. Wallacei*).

Selaginella peruviana var. *Dombeyana* Hieron. in Hedwigia 39:308. 1900. (Lectotype: *Bang 111* B!. Paratypes: *Mandon 84* B!; *Dombey 14* B! sterile; Bolivia, March 20, 1892, *O. Kuntze* B; Argentina, *Hieronymus & Lorentz 162* B; Argentina, Jan. 1874, *Lorentz & Hieronymus* B).

Selaginella Sheldonii Maxon, in Proc. Biol. Soc. Wash. 31:171. 1918, as *Sheldoni*. (Holotype: *Sheldon 233* US!. Paratypes: *F. C. Greene* on June 10, 1918 US!, on May 4, 1918 US!; *Jermy 343* US!; *Havard* US!; *Wooton* US!).

Upper leaves herbaceous, or fleshy only at the base, linear, acuminate, to linear-long-triangular; under leaves herbaceous, subulate, acuminate, broadest at or very near the base, to rarely linear-lanceolate, a little longer than the upper on the same portion of the stem; leaves setate in the bud, setae persistent (part may be abraded), stout, straight, those of the under leaves 0.5–1.0 mm. long, rarely some 0.3 mm. long. Megaspores rather coarsely rugose-reticulate on the commissural face, less prominently marked on the outer face, yellow to bright orange.

S. peruviana is the least specialized member in the series and for this reason it is considered as the basic type. Some four collections of the many examined (*Stanford et al. 118* MO, *Steyermark 52276* F, *Arsène 7087* US, *Sharp 44257* US) show a tendency toward *S. arizonica* in having either relatively thin under leaves or short (0.2–0.3 mm.) setae. The primary characters of *S. peruviana* are the narrow under leaves, the long setae and the similar texture of the upper and under leaves.

The localities taken from the literature (map 52) are from Alston, in Physis 15:253. 1939.

Bluffs, rocky slopes or on ledges and in crevices of cliffs, exposed or under light shade, igneous rocks or sandstone, less often in sandy or clay soil, 600–3000 m. in the United States, 1300–3200 m. in Mexico and 1900–4000 m. in South America.

Oklahoma and New Mexico to Puebla; Peru to Argentina.

Representative specimens:

UNITED STATES. OKLAHOMA: *Goodman 2337* (GH, MO, NY, US); May 4, 1918, *F. C. Greene* (US), June 10, 1918 (US); Quanah Mountain, Indian Territory, July 28, 1891, *Sheldon 233* (US). TEXAS: July, 1883, *Havard* (US); *Jermy 343* (MO, US); *Lindheimer 77* (GH, MO, US); *C. H. Mueller 8256* (GH, MO, NY, US); *R. M. & A. F. Tryon 5032* (BM, CU, DS, GH, MIN, MO, PH, POM, US, WS); March 7, 1918, *Wooton* (US). NEW MEXICO: *Arsène 18050* (F, US), *18613* (F, US); *Arsène & Benedict 16838* (F, US).

MEXICO. *Aschenborn 65* (B). COAHUILA: *Stanford et al. 118* (GH, MO, NY, US). CHIHUAHUA: *E. Palmer 38* in 1908 (GH, US). DURANGO: *E. Palmer 554* in 1896 (GH, US). MEXICO: *Schaffner 933* (GH, YU). DISTRITO FEDERAL: *Schaffner 10* (B, BM).

PERU: *Cook & Gilbert 158* (US), *240* (US), *305* (US), *608* (US); *Dombey 14* (B, P); *Soukup 1885* (GH, US), *3571* (MO); *Stork & Horton 9388* (F); Huanuco, *Ruiz 98* (B, P); *Vargas 3141* (F), *11058* (F).

BOLIVIA: Vicinity of La Paz, 10,000 ft., 1889, *Bang 111* (B, F, GH, K, MO, P, US); *Buchtien 4299* in 1919 (F, MO, US); *Eyerdam 24798* (F); *Mandon 84* (B), *1531* (B).

ARGENTINA: *Burkart 10112* (MO); *Hieronymus & Lorentz 162* (P); *Lossen 426* (F, MO).

40. SELAGINELLA ARIZONICA Maxon, in Smiths. Misc. Coll. 72[5]:5. 1920. (Holotype: *Shreve* US!. Paratypes: *Thornber 315* US!; *Cook* US!; *Parish 8513* US!; *P. F. Mohr* US!; *Toumey* US!; *Goodding 722* US!; *Bailey* in 1913 US!, on Nov. 9, 1913 US!). Figs. 57, 58. Map 53.

Upper leaves fleshy, lanceolate to linear-lanceolate; under leaves papyraceous, lanceolate to lanceolate-ovate, broadest above the base, about as long as to slightly longer than the upper on the same portion of the stem; leaves setate in the bud, setae predominantly (or many) persistent, stout, straight, those of the under leaves 0.1–0.3 mm. long. Megaspores rather finely rugose-reticulate on the commissural face, less prominently marked on the outer face, pale orange.

S. arizonica is characterized by its short setae and thin and broad under leaves. It is rather closely related to *S. peruviana* and some specimens of that species approach *S. arizonica* in having relatively thin under leaves or short setae. In Texas the two sometimes grow in the same mat but these mixtures are readily separable. Some strobili of *A. & R. A. Nelson 1158* MO have vegetative growth beyond the tip, a condition not uncommon in *S. arenicola* ssp. *Riddellii*.

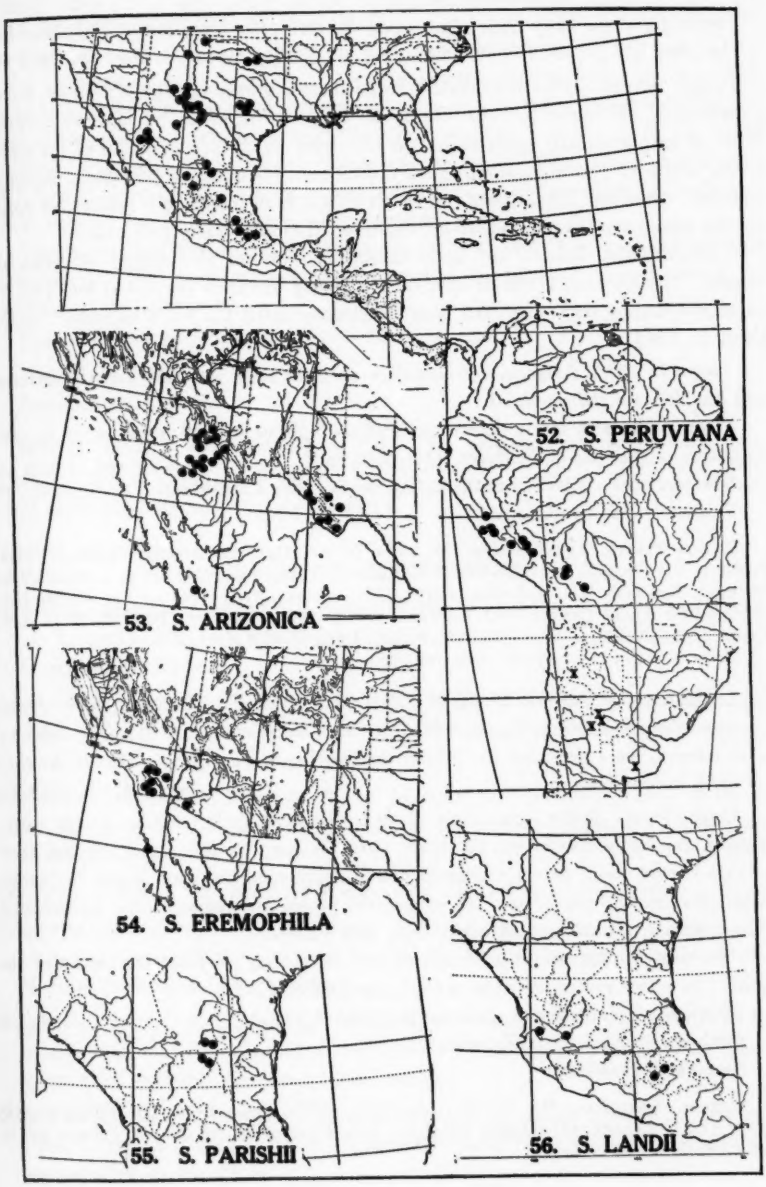
Exposed rocky places, in crevices or on ledges, or in gravel, usually on igneous rock, rarely on limestone, 600–2000 m.

Southwestern Texas, Arizona and adjacent Sonora, Baja California.

Representative specimens:

UNITED STATES. TEXAS: *Cory 6878* (GH), *40232* (GH, US); *Hinckley 2147* (GH); June 6, 1924, *Orcutt* (GH, US); *R. M. & A. F. Tryon 5048* (ARIZ, FI, MICH, MO, PH, POM, RM). ARIZONA: Nov. 9, 1913, *V. Bailey* (US), 1913, *V. Bailey* (US); 1913, *O. F. Cook* (US); *Goodding 722* (GH, NY, US); April, 1873, *P. F. Mohr* (US); *Nelson 11217a* (GH, NY, US); *Parish 8513* (US); *Phillips 2030* (GH, MO, US); Foot of Soldier Trail, Santa Catalina Mountains, July 28, 1914, *Shreve* (GH, MO, NY, US); *Thornber 315* (US); April 3, 1894, *Toumey* (US); *R. M. & A. F. Tryon 5052* (B, BM, F, GH, K, MO, NY, P, UC, US).

MEXICO. SONORA: *Mearns 2701* (B, US); *Wiggins 8330* (US). BAJA CALIFORNIA: Oct. 26, 1930, *M. E. Jones* (BM, MO, US).


52. S. PERUVIANA
53. S. ARIZONICA
54. S. EREMOPHILA
55. S. PARISHII
56. S. LANDII

41. SELAGINELLA EREMOPHILA Maxon, in Smiths. Misc. Coll. 72[5]:3. 1920. (Holotype: *Johnston 1047* US!. Paratypes: *Mearns 3162* US!; *Bethel* US!; *Saunders* in 1908 US!; *Hall* US!; *Parish 6111* US!; *Dudley* US). Fig. 59. Map 54.

Upper leaves fleshy, lanceolate-triangular to ligulate-triangular; under leaves papyraceous, to herbaceous at the apex, ligulate-lanceolate to lanceolate-ovate, about as long as to half again as long as the upper on the same portion of the stem; leaves setate in the bud, setae entirely deciduous to casually persistent, delicate, filiform, tortuous. Megaspores rugose-reticulate with irregularly projecting rugae on the commissural face, rugose-reticulate on the outer face, pale yellow.

The tortuous, delicate and early deciduous setae set this species off from all others. The setae are attached only on the young leaves in the apical bud and are so inconspicuous that they had been overlooked until C. A. Weatherby[24] noted them in 1943.

Jaeger in 1934, Arizona, is unusual in that the setae are only slightly tortuous and less delicate than normal.

Open rocky and sandy deserts, in sheltered places in rock crevices or in sand or gravel at the base of boulders, 130–1000 m.

Southwestern Arizona, southern California, Baja California.

Representative specimens:

UNITED STATES. ARIZONA: Dec. 17, 1934, *Jaeger* (US). CALIFORNIA: April 17, 1918, *Bethel* (US); Dec. 25, 1903, *Dudley* (US); March, 1919, *Hall* (US); Palm Canyon (Palm Springs), Riverside Co., *Johnston 1047* (US); *Mearns 3162* (NY, US); *Parish 1200* (NY); *Rose 45342* (MO); 1903, *Saunders* (NY), 1908, *Saunders* (US); *R. M. & A. F. Tryon 5057* (B, BM, F, GH, MO, NY, P, UC, US); *Wolf 8461* (GH).
MEXICO. BAJA CALIFORNIA: *Wiggins 9981* (US).

42. SELAGINELLA PARISHII Underw. in Bull. Torr. Bot. Club 33:202. 1906. (Holotype: *Palmer 306* NY. *Parish 1200* and *Saunders* in 1903, also cited by Underw., were excluded by Maxon, in Smiths. Misc. Coll. 72[5]:4. 1920; they are *S. eremophila*. Figs. 60, 61. Map 55.

Upper leaves fleshy, lanceolate to lanceolate-triangular; under leaves papyraceous, lanceolate-ovate, up to about twice as long as the upper on the same portion of the stem; leaves muticous, the slightly modified apex acute to obtuse. Megaspores rugose-reticulate with irregularly projecting rugae on the commissural face, rugose-reticulate on the outer face, pale yellow.

The muticous leaves are sufficient to set this species off from the others of the series. In a few specimens some strobili are dorsiventral.

Crevices of sandstone or slate rocks, 1700–2300 m.

Coahuila and adjacent Zacatecas.

Specimens examined:

MEXICO. COAHUILA: *Nil 105 (Arsène 3453)* (US); June, 1909, *Nil* (US); *Pennell 17272* (US). ZACATECAS: *Chaffey 58* (US); near Concepción del Oro, *E. Palmer 306* in 1904 (F, GH, MO, US).

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[24] Amer. Fern Jour. 33:115. 1943.

43. SELAGINELLA LANDII Greenm. & Pfeiff. in Ann. Mo. Bot. Gard. 5:205. 1918. (Holotype: *Barnes & Land 2024* MO!). Figs. 62, 63. Map 56.

Upper leaves fleshy, long-deltoid, or with parallel sides toward the base; under leaves papyraceous, lanceolate-ovate to ovate, acuminate, more than twice to 2½ times as long as the upper on the same portion of the stem; leaves muticous to short-setate, the upper muticous with the slightly modified apex obtuse, the under muticous or usually with a short, stout seta up to 0.3 mm. long. Megaspores slightly and finely rugose on the commissural face, slightly rugose, granular, to nearly smooth on the outer face, yellow-orange.

This is the most specialized species of the series in that it is the most strongly dorsiventral. The short-setate under leaves and the muticous upper leaves are sufficient to characterize it.

Dry rocks and on boulders, 1700–4000 m.

Nayarit to Puebla.

Specimens examined:

MEXICO. NAYARIT: *M. E. Jones 23495* (MO, US). JALISCO: *Barnes & Land 153* (F), San Estebán Mountains, ca. 32 km. from Guadalajara, 1908, *Barnes & Land 2024* (GH, MO, US); *Pringle 10823* (GH, US); *Rose & Painter 7499* (US). MORELOS: *Matuda 26352* (MO, US). PUEBLA: *Kenoyer 25* (US).

DUBIOUS AND REJECTED NAMES

Lycopodium struthioloides Nutt. ex Baker, Handb. Fern Allies, 35. 1887, in synon., not Pr. 1825. The brief description is not sufficient to place this name although it suggests S. *Watsonii*.

Selaginella rupestris (L.) Spring var. *borealis* Spring, in Nouv. Mém. Acad. Roy. Belg. (Monog. Fam. Lycopod.) 24:57. 1850. Indirectly based on a variety of specimens representing many species.

Selaginella rupestris var. *brevipila* A. Br. in Ann. Sci. Nat. V, 3:270. 1865, in synon. Some of the specimens cited under the accepted name, S. *rupestris*, are S. *Sellowii*, others are S. *Sartorii*.

Selaginella rupestris var. *longipila* Fourn. Mex. Pl. 1:146. 1872, nomen nudum.

Selaginella rupestris var. *longipila* subvar. *glaucina* Fourn. Mex. Pl. 1:146. 1872, nomen nudum. *Wright 1820* is S. *Sellowii*. The other specimens cited undoubtedly represent other species.

Selaginella rupestris var. *longipila* subvar. *viridis* Fourn. Mex. Pl. 1:146. 1872, nomen nudum. *Bourgeau 2541* and *Bottéro 78* are S. *extensa;* the other specimens cited probably represent other species.

Selaginella rupestris var. *tropica* Spring, in Nouv. Mém. Acad. Roy. Belg. (Monog. Fam. Lycopod.) 24:57. 1850. Indirectly based on a variety of specimens representing many species.

Selaginella struthioloides (Presl) Underw. Bull. Torr. Bot. Club 25:132. 1898. (*Lycopodium struthioloides* Presl, Rel. Haenk. 1:82. 1825.)

Maxon (Amer. Fern Jour. 11:35–36. 1921) has discussed the misapplication of Presl's name by Underwood to *Selaginella oregana*. In addition to the characters of size mentioned by Maxon, I may add other reasons supporting his position. First, *Selaginella oregana* is not known to grow on Vancouver Island; the nearest station for it is about 160 miles south of Nootka Sound, the locality cited for *Lycopodium struthioloides*. Second, Presl would certainly have placed a specimen of *Selaginella oregana*, with its definite strobilus, under his heading "Spicis sessilibus" rather than under "Capsulis axillaribus" where he placed *Lycopodium struthioloides* and other species without strobili. Finally, Greville and Hooker, in Bot. Misc. 3:105. 1833, say of *Lycopodium struthioloides* Presl: "We have examined Haenke's specimen, named by Presl himself, in the Lambertian Herbarium; and find it to be in no respect different from *L. laxum* of that author, which also exists in the same collection." *Lycopodium laxum* is placed by Herter, Index Lycopod. 55. 1949, as a synonym of *Urostachys carinatus* (Desv.) Hert. (*Lycopodium carinatum* Desv.), a species of southeastern Asia. This evidently represents another example of a mixture of Haenke's labels.

LIST OF SPECIES

1. S. RUPINCOLA Underw.
   - 1a. S. × NEOMEXICANA Maxon
2. S. BIGELOVII Underw.
3. S. ARENICOLA Underw.
   - 3a. S. ARENICOLA ssp. RIDDELLII (Van Eselt.) Tryon
     - 3a-b. Intermediate between ssp. RIDDELLII and ssp. ARENICOLA
   - 3b. S. ARENICOLA ssp. ARENICOLA
     - 3b-c. Intermediate between ssp. ARENICOLA and ssp. ACANTHONOTA
   - 3c. S. ARENICOLA ssp. ACANTHONOTA (Underw.) Tryon
4. S. BALANSAE (A. Br.) Hieron.
5. S. WEATHERBIANA Tryon
6. S. VIRIDISSIMA Weath.
7. S. TORTIPILA A. Br.
8. S. SELLOWII Hieron.
9. S. SARTORII Hieron.
10. S. WIGHTII Hieron.
    - 10a. S. WIGHTII var. WIGHTII
    - 10b. S. WIGHTII var. PHILLIPSIANA Hieron.
11. S. CINERASCENS A. A. Eaton
12. S. ARSENEI Weath.
13. S. MACRATHERA Weath.
14. S. SHAKOTANENSIS (Franch. ex Takeda) Miyabe & Kudo
15. S. WALLACEI Hieron.
16. S. MUTICA D. C. Eaton ex Underw.
    - 16a. S. MUTICA var. LIMITANEA Weath.
      - 16a-b. Intermediate between var. LIMITANEA and var. MUTICA
    - 16b. S. MUTICA var. MUTICA
17. S. EXTENSA Underw.
18. S. WRIGHTII Hieron.
19. S. STEYERMARKII Alston
20. S. HANSENII Hieron.
21. S. CARINATA Tryon
22. S. INDICA (Milde) Tryon
23. S. NJAMNJAMENSIS Hieron.
24. S. CAFFRORUM (Milde) Hieron.
25. S. ECHINATA Baker
26. S. NIVEA Alston
27. S. PROXIMA Tryon
28. S. DREGEI (Presl) Hieron.

29. S. VARDEI Lév.
30. S. OREGANA D. C. Eaton
31. S. UNDERWOODII Hieron.
32. S. RUPESTRIS (L.) Spring
33. S. DENSA Rydb.
    - 33a. S. DENSA var. SCOPULORUM (Maxon) Tryon
    - 33a-b. Intermediate between var. SCOPULORUM and var. DENSA
    - 33a-c. Intermediate between var. SCOPULORUM and var. STANDLEYI
    - 33a-b-c. Intermediate between var. SCOPULORUM, var. DENSA and var. STANDLEYI
    - 33b. S. DENSA var. DENSA
    - 33b-c. Intermediate between var. DENSA and var. STANDLEYI
    - 33c. S. DENSA var. STANDLEYI (Maxon) Tryon
34. S. SIBIRICA (Milde) Hieron.
35. S. WATSONII Underw.
36. S. UTAHENSIS Flowers
37. S. LEUCOBRYOIDES Maxon
38. S. ASPRELLA Maxon
39. S. PERUVIANA (Milde) Hieron.
40. S. ARIZONICA Maxon
41. S. EREMOPHILA Maxon
42. S. PARISHII Underw.
43. S. LANDII Greenm. & Pfeiff.

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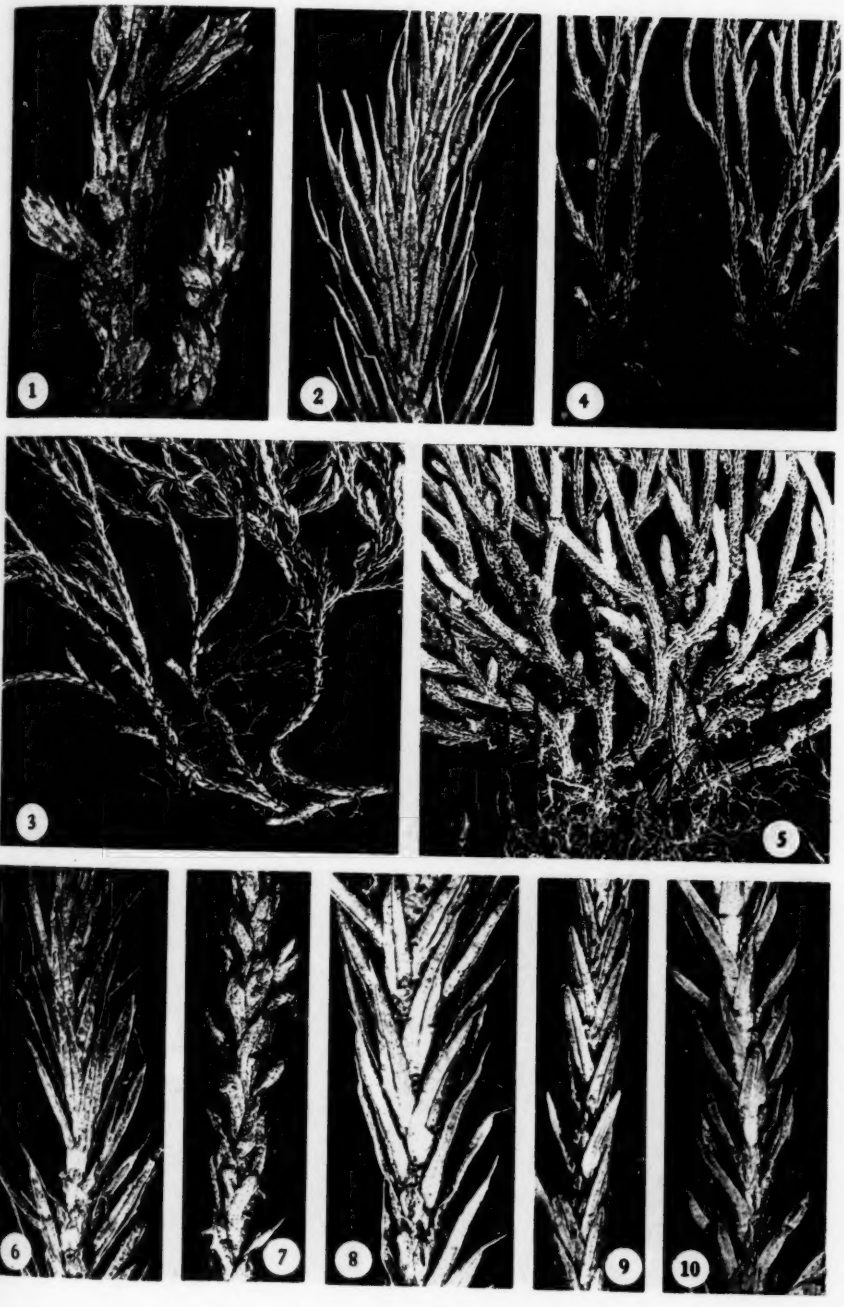
Accepted names are in Roman type; synonyms and rejected names are in *italic;* names of subgeneric categories are in CAPITALS.

Explanation of Plate

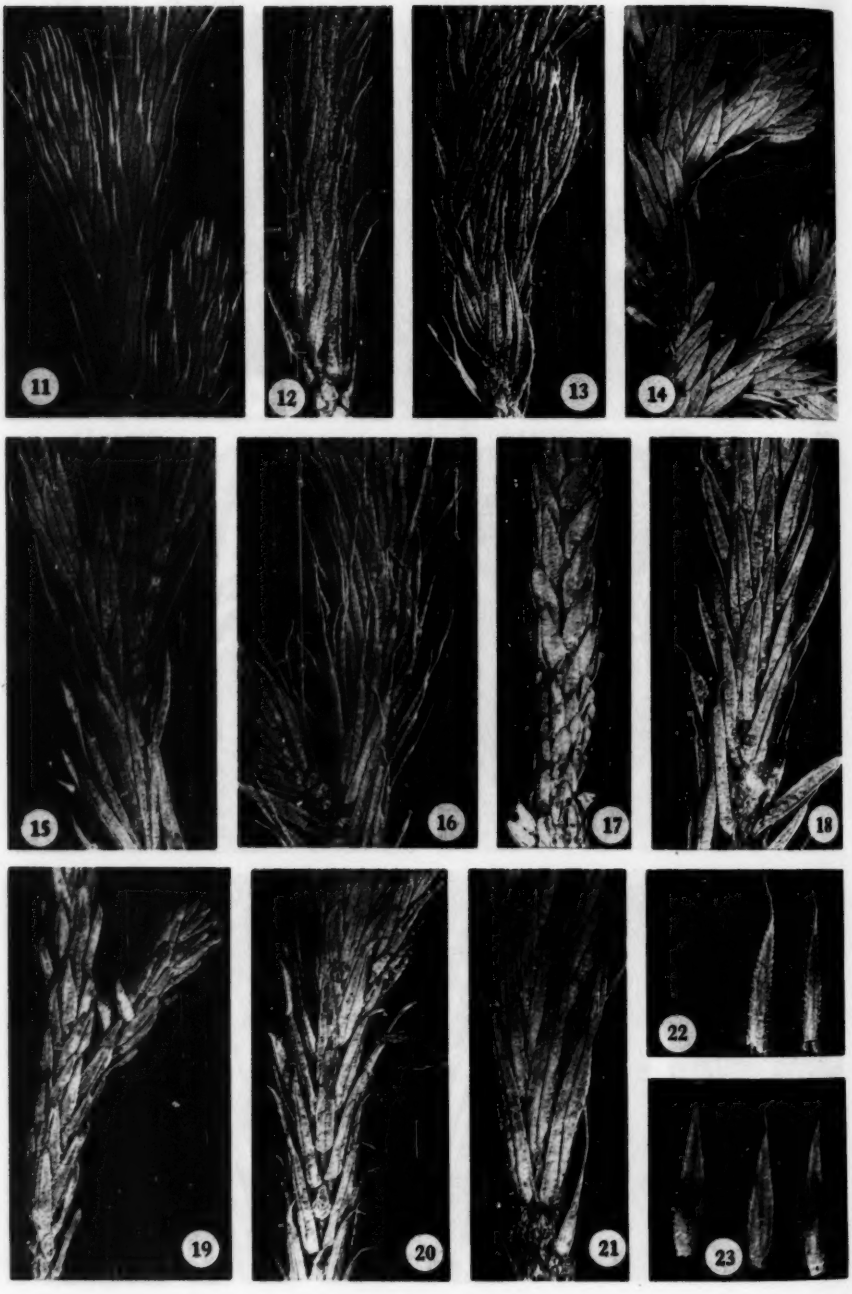
PLATE 1

Series Arenicolae

Fig. 1. S. *rupincola*, buds at ground level, *Tryon & Tryon 5051* (MO), × 10.
Fig. 2. S. *rupincola*, portion of aerial stem, *Wooton 124* (NY), × 10.
Fig. 3. S. *Bigelovii*, branching rhizome and basal portion of aerial stems, *Tryon & Tryon 5053* (MO), × 1.75.
Fig. 4. S. *arenicola* ssp. *arenicola*, stems with basal buds and rhizophores, *Tryon 5016* (MO), × 1.75.
Fig. 5. S. *arenicola* ssp. *acanthonota*, basal portion of stems, *Tryon 5009* (MO), × 1.75.
Fig. 6. S. *Balansae*, portion of aerial stem, *Balansa* (P), × 10.
Fig. 7. S. *Weatherbiana*, portion of rhizome, *Tryon & Tryon 5077* (MO), × 10.
Fig. 8. S. *Weatherbiana*, portion of aerial stem, *Standley 4558* (MO), × 10.
Fig. 9. S. *viridissima*, portion of aerial stem, Stewart *2204* (GH), × 10.
Fig. 10. S. *tortipila*, portion of aerial stem, *Rugel* (US), × 10.



TRYON — *SELAGINELLA RUPESTRIS* AND ALLIES



TRYON — *SELAGINELLA RUPESTRIS* AND ALLIES

Explanation of Plate

PLATE 2

Series Sartorii

Fig. 11. S. *Sellowii*, portion of stem, upper side, *Venturi 1866* (US), × 10.

Fig. 12. S. *Sartorii*, portion of stem, upper side, *Liebmann* (GH), × 10.

Fig. 13. S. *Wightii* var. *Wightii*, portion of stem, upper side, *Ferguson* (US), × 10.

Fig. 14. S. *cinerascens*, portion of stem, upper side, *Kimball* (GH), × 10.

Fig. 15. S. *Arsenei*, portion of stem, upper side, *Arsène 10641* (US), × 10.

Fig. 16. S. *macrathera*, portion of stem, upper side, *Johnston 8067* (GH), × 10.

Fig. 17. S. *shakotanensis*, strobilus, *Faurie 9895* (MO), × 10.

Fig. 18. S. *Wallacei*, portion of stem, upper side, *Wallace* (NY ex B), × 10.

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Fig. 20. S. *extensa*, portion of stem, upper side, *Pringle 3900* (GH), × 10.

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Fig. 22. S. *Steyermarkii*, upper leaves, *Hatch & Wilson 325* (US), × 10.

Fig. 23. S. *Steyermarkii*, under leaves, the dark areas are colored red, *Hatch & Wilson 325* (US), × 10.

EXPLANATION OF PLATE

PLATE 3

Series SARTORII

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Fig. 26. *S. carinata*, portion of stem, upper side, *Rose et al. 23039* (US), × 1.25.

Fig. 27. *S. indica*, portion of stem, under side, *Hooker & Thomson* (P), × 10.

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Fig. 33. *S. proxima*, portion of stem, upper side, *Humbert & Swingle 5705* (US), × 10.

Fig. 34. *S. proxima*, sporophylls from upper side of strobilus, *Humbert & Swingle 5705* (US), × 10.

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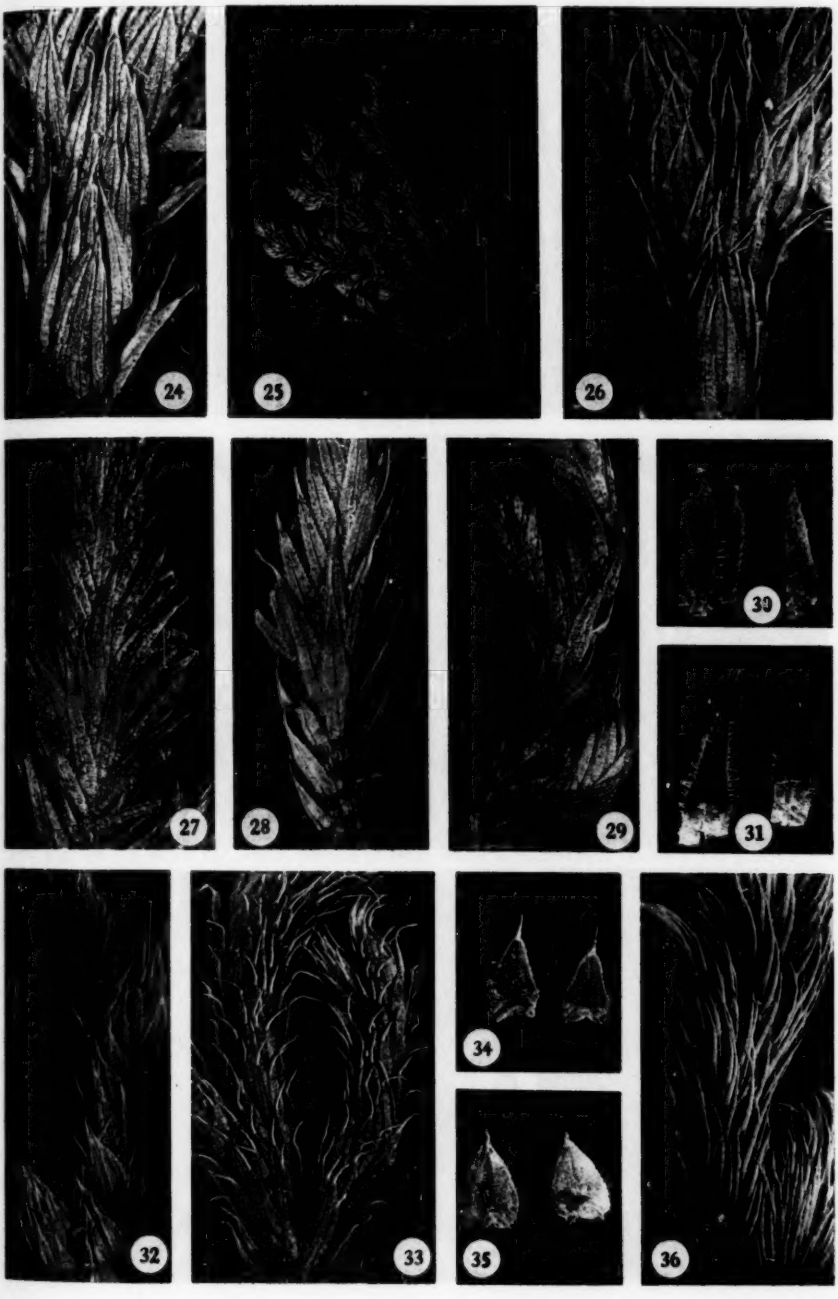
Fig. 36. *S. Dregei*, portion of stem, lateral view, *Rodin 4403* (MO), × 10.



TRYON — *SELAGINELLA RUPESTRIS* AND ALLIES

TRYON — *SELAGINELLA RUPESTRIS* AND ALLIES

Explanation of Plate

PLATE 4

Series Rupestres

Fig. 37. *S. Vardei*, portion of stem, upper side, *E. H. Wilson 5411* (P), × 10.

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Explanation of Plate

PLATE 5

Series Rupestres

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Fig. 49. *S. Watsonii*, portion of mat, *Tryon & Tryon 5060* (MO), × 1.

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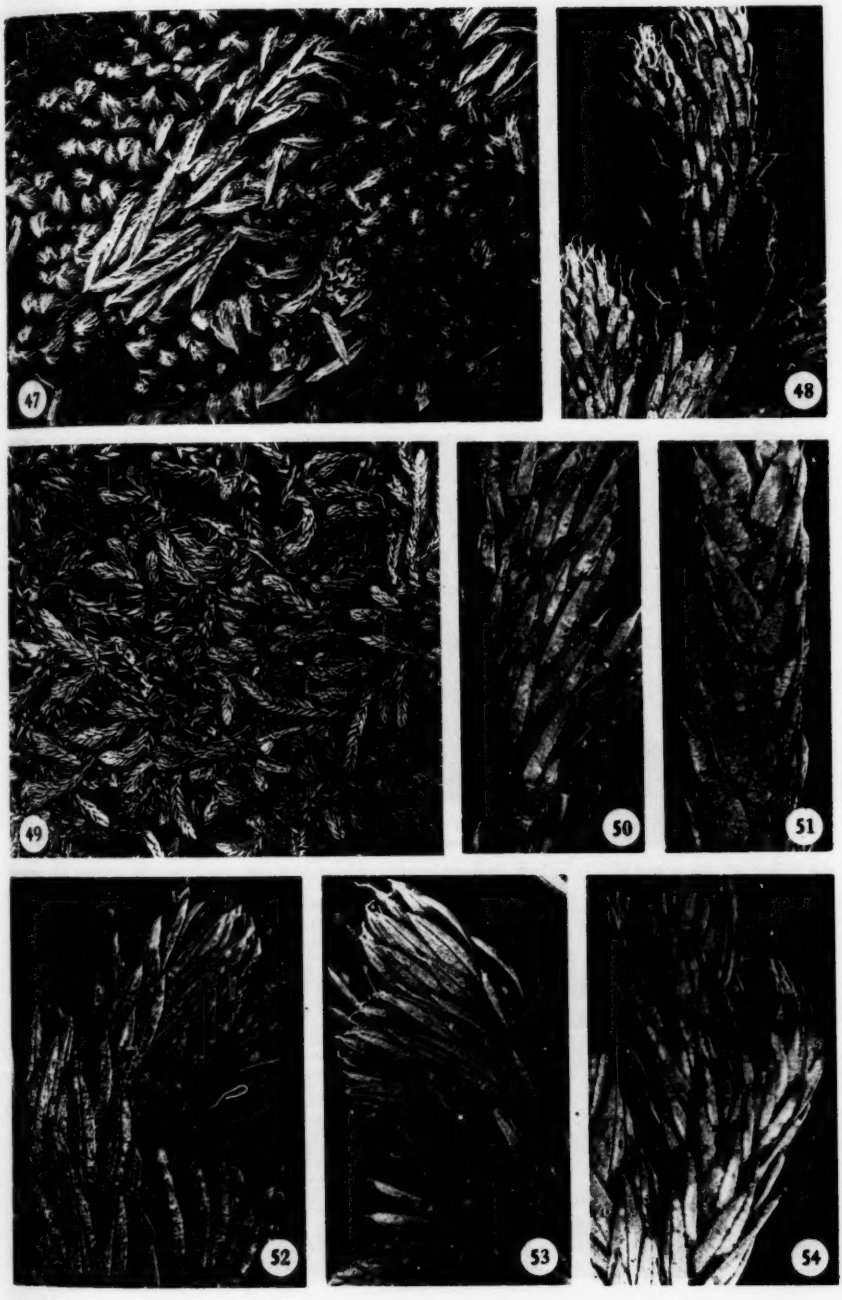
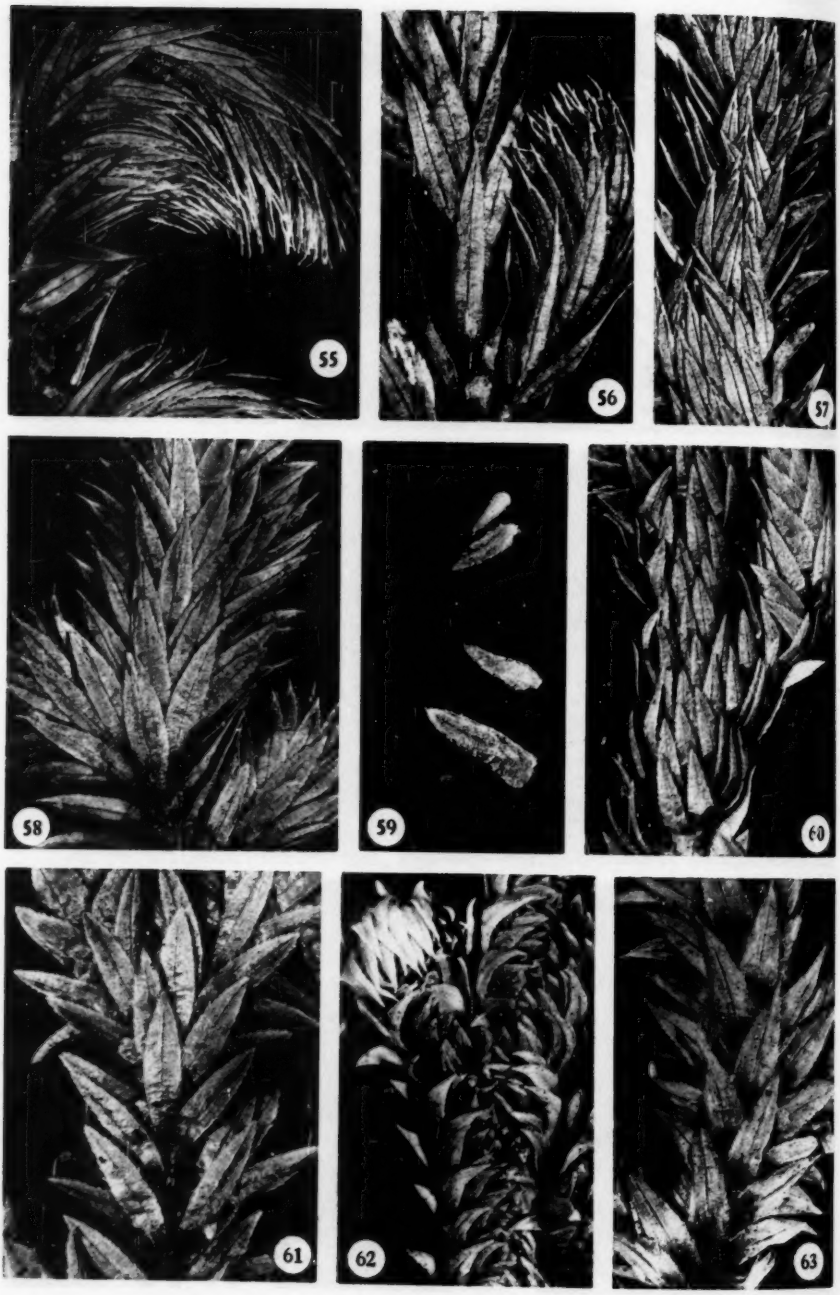


TRYON — *SELAGINELLA RUPESTRIS* AND ALLIES



TRYON — *SELAGINELLA RUPESTRIS* AND ALLIES

Explanation of Plate

PLATE 6

Series Eremophilae

Fig. 55. *S. peruviana*, tip of stem in dormant state, *Tryon & Tryon 5031* (MO), × 10.

Fig. 56. *S. peruviana*, portion of stem, under side, *Soukup 1885* (US), × 10.

Fig. 57. *S. arizonica*, portion of stem, upper side, *W. S. Phillips 2588* (US), × 10.

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Fig. 61. *S. Parishii*, portion of stem, under side, *E. Palmer 306* (GH), × 10.

Fig. 62. *S. Landii*, portion of stem in dormant state, upper side, *Pringle 10823* (GH), × 10.

Fig. 63. *S. Landii*, portion of stem, under side, *Pringle 10823* (GH), × 10.

A NEW PELLAEA FROM SOUTH AFRICA*

ALICE F. TRYON

PELLAEA **rufa** sp. nov., A. F. Tryon. Rhizoma gracile repens dichotomum paleis concoloribus rufis elongato-lanceolato-triangularibus acumine filiformi basi cordata. Folia 12–30 cm. longa stipite rufo rachide rufa apicem versus flexuosa. Laminae elongato-triangulares bi-tripinnatae segmentis ellipticis vel ovatis vel nonnullis ternatis coriaceis nervis immersis. Sporangia brevissime stipitata. Sporae pallide luteolo-fuscae triplantae laeves. Typus: *Compton 16402* (US).

Rhizome slender, cord-like, dichotomously branched, long creeping. Scales of the rhizome and stipe-base concolorous, ruddy-tan, elongate lanceolate-triangular, sparsely dentate, the tip filiform, the base cordate, scales surrounding the meristem pinkish or red. Fronds 12–30 cm. long, approximate, the buds paleaceous. Stipe and rachis convex or plane on the upper surface, nearly glabrous, ruddy-tan to red becoming darker and gray with age, the upper portion of the rachis usually flexuous. Blade 10 cm. long and 2 cm. broad to 25 cm. long and 5 cm. broad, bi-tripinnate, elongate-triangular, the pinnae ascending at a broad angle to the rachis, the rachises somewhat flexuous. Segments 3 mm. long and 2 mm. broad to 10 mm. long and 6 mm. broad, elliptical or oval (some ternate), retuse, coriaceous, the veins immersed and obscure, the margin reflexed or revolute, border lutescent, crenulate, the young segments reddish. Sporangia with short stalks less than one-fourth the capsule length. Spores 64 per sporangium, tetrahedral, pale yellowish-brown, essentially smooth.

Specimens examined:

CAPE PROVINCE: Rock crevices, Ngaap Kop, Laingsburg Dist., Nov. 6, 1944, *R. H. Compton 16402* (US); Same locality, Dec. 1, 1941, *R. H. Compton 12619* (US); Foothills of Witteberg, April 19, 1925, *R. H. Compton 2961* (K); Rocky hillsides among succulents, The Great Karoo, near Matjiesfontein, Jan. 24, 1948, *Robert J. Rodin 3342* (UC, K, MO); Karoo, Groote Fontein, *Mr. Dickson*, Lady Barkly recd. 5/75 (K); Locis rupestribus montosis, siccis in dumetris, Kendo, alt. 3000–4000, 1838, *Drège* (BM, K, MO, P).

Additional localities from the Cape Province have been cited by Compton[1] from—Whitehill Ridge; Klipbank, Beaufort West Div.; and by Alston and Schlepe[2] from—Sutherland: Klein Roggeveld, Schietfontein.

This fern of the South African Karroo has had an elusive record for some hundred years. It is not surprising for the species is strange among African ferns having its closest ally, *Pellaea myrtillifolia* in the xermorphic flora of central Chile. These and two species in the southwestern United States form an alliance so close

[1] Trans. Roy. Soc. South Africa 19:270. 1931.
[2] Jour. South African Botany 18:170. 1952.

* This paper was prepared in connection with a grant from the Bache Fund of the National Academy of Sciences for the study of desert ferns.

Issued March 24, 1955.

that they were long considered as a single species. Another member of the genus, *P. ovata*, with a widespread Cordilleran range is more distantly related. Affinities of these species are easily seen in the unique, reddish color of the stipe and rachises and of the segments particularly on the immature frond. They are likewise expressed in the elongate-triangular form and generally tripinnate division of the blade, in the elliptical, retuse form of the segments and elongate, basally cordate scales. *P. andromedaefolia* of California and *P. intermedia* of southern Arizona, New Mexico, Texas and adjacent Mexico are distinguished from the Chilian and African plants in having the rhizome scales with a sclerotic central stipe. The rugose spores and compact, multicipital rhizome of *P. myrtillifolia* distinguish the Chilian plant from *P. rufa*.

The first collection, made by Drège was included by Kunze[3] under *Allosorus andromedaefolius* along with collections from California and Chile. Hooker[4] retained these under *Pellaea andromedaefolia*. The Chilian species was segregated in Kuhn's publication on the Mettenius manuscript.[5]. Later authors regarded the African record as erroneous and it was excluded until reinstated by Marloth[6], Compton and more recently by Alston and Schlepe as *P. andromedaefolia*.

The range of the species is local largely within a radius of 40 miles in the vicinity of Whitehill. Several of the collections, including the type, were made by Professor Compton whose regard for this area has resulted in an extensive flora of the Whitehill District and a Botanical Reserve for the preservation of Karroo plants. The species occurs on dry, rocky hillsides at an elevation of 3,000–4,000 feet under 5–6 inches of rainfall. It is apparently able to make rapid growth during the January rains and to tolerate long periods of desiccation. Adaptations to this environment in other genera as *Mesembryanthemum*, *Crassula*, *Helichrysum* and *Stapelia* have resulted in the striking xeromorphic flora of the Karroo.

Related species of *Pellaea* in Chile and the Southwestern United States exist under environmental conditions of essentially the same extremes. The distribution of such closely allied species in three distant regions is not a unique one. Such relationships particularly between South Africa and South America have been treated at considerable length in studies on the origin of the flora of South Africa as well as in systematic treatments of several plants and animals as the earthworms *Acanthodrilus*, the rosaceous genus *Acaena*, and *Menodora* of the *Oleaceae*. The range of the latter[7] is nearly identical to these species of *Pellaea*. Evidence from these closely related species of ferns supplies additional data on the floristic relationships of three continents.

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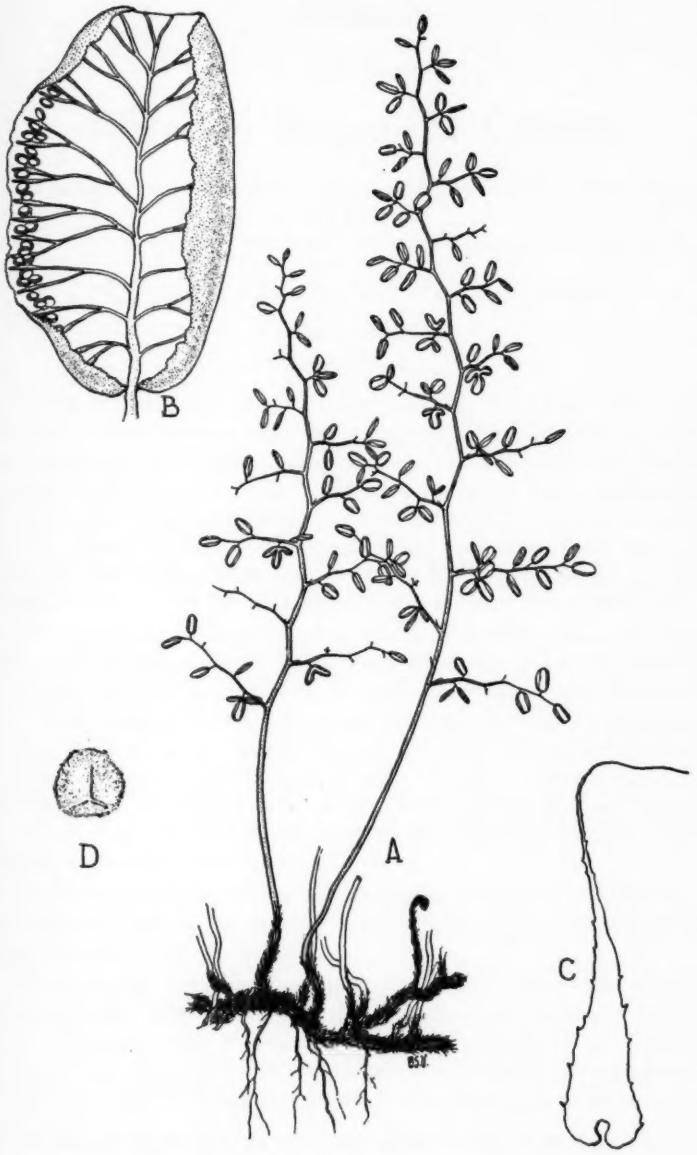
[3]Linnaea 10:503. 1836.
[4]Species Filicum 2:149. 1858.
[5]Linnaea 36:85. 1869.
[6]Das Kapland in Wiss. Ergeb. Deutschen Tiefsee-Exped. auf "Valdivia" 2^3:276. 1908.
[7]Steyermark, in Ann. Mo. Bot. Gard. 19:100. 1932.



Pellaea rufa: A, habit × ¾; B, segment with vein-ends exposed; C, rhizome scale; D, spore.